MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

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NOVEMBER 1926

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Mechanical Engineering

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ADVERTISING

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C. E. Lucke

E. Kwartz

A. Black

C. F. Bailey

D. H. Atherton

S. Timoshenko

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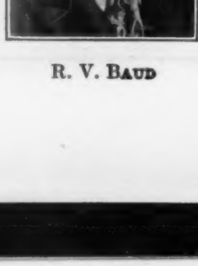

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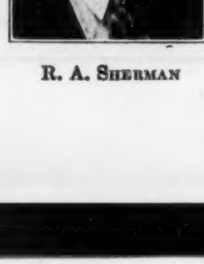

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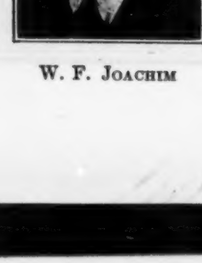

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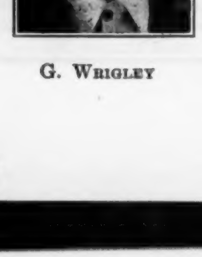

G. Wrigley

MECHANICAL ENGINEERING

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Engineering

A Discussion of the Part Played by Engineering in Industrial Affairs, the Major Classifications, Training the Individual, and the Basis for Public Interest

By CHARLES EDWARD LUCKE,[1] NEW YORK, N. Y.

ENGINEERING is a profession and as such stands beside law and medicine. It is not a trade, though it is in contact with the trades. It is not a business, even though it has become a necessity to modern big businesses. Nor is it a science, through based on the exact sciences of physics, chemistry, and mathematics, and in its practice the engineering method is essentially scientific.

Engineering is concerned with utility, with the creation of services and things for public use, especially new kinds, better. more useful or more economical than were available before. All of the discoveries of scientific study and research are sought by the engineer as a possible basis for some new sort of product, some improved process, or some better public service. The development stage, from the conception, the way in which some betterment might be effected, to its commercial realization, and, in addition, the most economical handling of the new thing, is strictly the engineer's affair. In this he acts as a director of the enterprise or technical expert over the whole or over any one of the more important or complicated parts. It is here that engineering becomes a bond between the activities of other groups, including all of the trades, the labor and skill of which do the actual work planned by the engineer; the bankers, who must find the funds to finance the enterprise; the industrial leaders, whose administration is needed; the merchants, who link producer with consumer; and at every step the lawyers, or, in the case of problems of more strictly public nature, the appropriate governmental departments or bureaus.

> *Engineering, although not a science, is based on the exact sciences of physics, chemistry, and mathematics, and in its practice the engineering method is essentially scientific. It is concerned with utility, with the creation of services and things for public use, especially new kinds, better, more useful, or more economical than were available before. A most absorbing, clean, satisfying, and unselfish game, the game of making nature work for man as man works for himself and his fellow-men, the finest and greatest game in the world.*

With professional activities so widespread as this, and so intimately knitted into the fabric of affairs of all the advanced nations, it is rather strange that so small a part of the public does really understand what engineering means, or what constitutes an engineer. Many explanations for this situation have been advanced, but of them all only two need be mentioned. The first is that the engineer acting in his professional capacity is usually an agent, not a principal; he is working out something or directing some undertaking for some one else, an individual, a corporation, or the Government, and the public hears of the principal but not of the agent. The second explanation is found in the attitude of the engineer himself, who, dealing with *things* primarily, the materials and the forces of nature, is so absorbed in the great natural laws, which he is trying to utilize in some new or better way, that he has developed a sort of impersonal attitude and an unwillingness to talk. The *thing* is so big and so absorbing that mere words seem trivial and inadequate, and talk a waste of valuable time.

Every discovery in the basic sciences, or in the principles of engineering, every invention and every engineering development gives birth to a new family of discoveries, inventions, principles, methods, and products, and this process results in a multiplication of ideas and useful results every year. As a consequence, engineering is growing in scope at an ever-accelerating rate in a sort of geometrical progression, somewhat like the multiple compounding of interest on investments. This fact has forced engineers, in the practice of their profession, to limit their activities to some one division in which it is possible for one man to become really expert, an authority; and so engineering itself has divided into definite branches, each well recognized. This division is still going on, and there is every reason to believe that further division will be made in the future, and new branches of the profession will be recognized as legitimate.

Major Classifications

At the present time there are four major divisions of engineering that are fully recognized, and many others only partly accepted as proper divisions, and so of minor importance, either because of smallness of number of members or because of lack of real justification.

The four major divisions include mining and metallurgical engineering, civil engineering, mechanical engineering, and electrical engineering.

The Mining Engineer concerns himself with the location of mineral deposits, including all the fuels and the ores of the metals, but it is his special problem to find and to apply the most economical methods of getting these natural resources out of the ground and into the general market for use. In the case of some of these materials he also undertakes the development of methods of treatment to get from them the greatest values or most useful materials derivable from them; and in the case of metals the metallurgical engineer directly coöperates by receiving the ores, removing the crude metal, and refining and treating each part up to the point of producing metals of all required properties in the most useful standard shapes and sizes.

The Civil Engineer plans and directs the construction of the great public works; highways and railroads; bridges and tunnels; river and harbor improvements; canals; water supply and sewage systems, including big-scale sanitation and land-reclamation projects, and other constructions of related nature.

The Mechanical Engineer deals with machinery of all kinds and with related tools, appliances, implements and apparatus, mainly constructed of metal. This includes machinery for generating power from any of the fuels, or from the water of streams; machinery utilizing power to manufacture some commodity, the so-called process machinery to produce textiles, cigarettes, printing, metal and wooden goods; machinery for some special service, such as pumping and refrigeration, heating and ventilating; machinery and apparatus for the other divisions of engineering to use, such as mine hoists, blowing engines for ore smelters, dredges and excavators, and equipment for chemical processes. It also includes that special large and important class, the machinery of transportation,

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Lecture broadcast from radio station WEAF, New York, N. Y., on the evening of May 10, 1926.

including the driven or carrying vehicles, steam and motorships and motorboats, locomotives and rail cars, automobiles, trucks and tractors, and aircraft; and, in addition, every sort of equipment for fuel utilization for any purpose whatever.

The Electrical Engineer, as the name implies, is skilled in all that concerns electricity and magnetism. He assumes responsibility for the utilization of electrical and magnetic principles, the development of equipment to get the most practical and economical results, and also, in the many cases where this is complicated, he undertakes its most efficient handling when it is put to work. This equipment includes electric generators for converting the mechanical power generated by engines and turbines into electricity; electric motors for converting electricity back again into mechanical power; and also the transmission of electric power from any number of generators to distant motors in any number. This electric transmission includes that large-scale enterprise of connecting many central power-generating stations with each other and with widespread transmission systems, even extending across several states, now known as superpower. In addition, there must be noted innumerable electrical appliances utilizing electricity as such, as distinguished from its utilization for power. Into this group fall the electric heating appliances, such as the large furnaces of the electrochemical industry, and also the electric lamp, the basis of all modern illumination. Finally, there is the particularly important and perhaps best-known class of apparatus in which electricity serves as the key to communication, that of the telegraph, telephone, and radio systems, which, acting with transportation, accomplish the linking of distant places, bringing their people and their products together.

Engineering Societies

The engineering profession is a highly organized one, and the evidence of this, independent of its actual practice day by day, is found in the engineering societies, and in a most voluminous and fast-growing body of literature in the form of books and periodicals. Each of the four major divisions of engineering is represented by a national society in this country, with an aggregate membership of over fifty-five thousand, coöperation being secured through a central organization, which is in effect the national representative of the engineering profession. There are equivalent societies abroad, all maintaining contact and working together for the advance of engineering, without regard to language or national boundaries. In fact, engineering has developed a sort of international language of its own—its terms, its drawings, its methods, its materials, its appliances, and its products are understood by the engineers of all nations, regardless of their spoken language.

In addition to the purely professional societies of the four major divisions noted, and perhaps a dozen or so minor ones, such as the chemical, marine, railroad, heating and ventilating, refrigeration, and automobile groups, there are perhaps a hundred semi-professional associations in which engineers join with business men, with bankers, or with men of the skilled trades in promoting some common interest involving problems beyond the scope of any one class. Among these may be mentioned, for purposes of illustration the National Electric Light Association, which is the central organization representing the business of generating electricity in central electric power stations and of its distribution to consumers, with a membership of fifteen thousand. The American Foundrymen and the Railroad Master Mechanics are also illustrations of this sort of associations of semi-professional, semi-business character. While no statistics are available, the aggregate membership must be somewhere near a quarter of a million in the United States alone.

Training

To enter the engineering profession a man must be trained, and a fair percentage must, in addition, be well educated to insure the vision and sympathetic contact with other men, especially non-engineers, that is so necessary to leadership of even the best-trained professional man. This training and education of engineers is also highly organized both in this country and abroad, and the very large number of students graduated each year by the engineering schools is immediately absorbed, with at least an equal number of men who succeed in rising from the ranks of the trades, and who, by study, qualify as professional engineers. In the engineering schools of the United States there are fifty-six thousand students enrolled, and eight thousand five hundred are graduated each year to begin the profession of engineering.

As a rule, the engineering schools of Europe are independent of the old universities, and in this country there are many such independent schools. It is quite typical of the United States, however, that most of our best universities have established engineering schools on a par with the law school, the medical school, and with the non-professional departments of university scholarship. This is regarded as a great step forward, because of the resulting contact between the representatives of the different professions affecting professional standards, and, in addition, the contact of the professional-school professors and students with the great body of non-professional scholars making up the rest of the university.

The Engineer in Industry

In the practice of engineering probably the most characteristic element is the point of view of the professional engineer, the basis of the engineering method. This, while founded on the exact sciences of physics and chemistry, and, therefore, properly named scientific, does not stop here, but must, and actually does, include an economic factor and, in some cases, also a sociologic one. Briefly, the engineer considers himself always as having a problem to solve, a problem of utility of some sort. A way must be found to do something or get something done, and the best possible way. Perhaps that thing has never been done at all, or perhaps it has been done but not in a satisfactory way. The first stage in the solution of such a problem is to assemble all possible ways in which the thing might be done, drawing on history, on past practices, on established principles, and on recent discoveries. Extensive knowledge of the subject is essential here, but it alone is not sufficient, because there must be capacity to recognize what things might apply to the case, somewhat similar to the capacity of a judge in a court of law to distinguish relevant from irrelevant evidence, and to apply the proper law to the case. This is the period of exploration, and in it lies the same lure that forms the foundation and motive for any exploration. It calls for the courage and fortitude of the crusader who will not give up, and it brings the same reward—satisfaction.

It is quite the common thing for the engineer to discover that some of his possible solutions are new and patentable inventions, and it is in just this way that most of the really useful inventions are made. They are solutions of problems worked out in a systematic effort to do something that is needed. Incidentally, there are more inventions of this sort produced per year in the United States than anywhere else in the world, and this is direct evidence of the great activity and productive fertility of American engineers.

Of all the possible solutions of a problem, some will be more suitable in one respect and less so in others. Some will be best adapted to existing tools, to the skill of available labor or to most available materials, to such plant or manufacturing facilities as are at hand; some will be more efficient or have greater reliability than others, and some will be most pleasing to one or another class of users for whom the problem is being solved, whether they know it or not. These are all questions of relative suitability as measures of value of the possible solutions, quite independent of the other phase of economics, that of dollars and cents, costs and selling prices, as factors in value. Of the several possible solutions of the problem some will be adapted to cheaper raw materials, or be producible at lower production costs; some will require less investment in equipment or in stock than others, and, with the best combination of these factors, some of the solutions will be cheaper than others. In these studies of comparative economics in relation to possible solutions of a given problem, it is very rare indeed to find that any one solution is best in every respect, so rare as to be regarded as almost a miracle. Furthermore, it is almost equally unusual to find that the solution which is really best, as to qualities or elements of suitability for the intended purpose, is also the cheapest; more often it is the most costly. Then comes the real judicial responsibility of the engineer because a new problem has arisen. Out of the too numerous solutions of the original problem of ways and means has now come the problem of economic selection, which requires an engineering decision. Engineers must make decisions, and in the long run they are themselves judged by their decisions, as is the case with other professional men, the lawyers and the phy-

sicians. All must be right much more often than wrong, and here the public is the final or real judge.

For a problem of major magnitude all this may take several years, as every doubtful point must be checked up and proved, even if costly experimentation is necessary, first in a laboratory and then later on a larger scale than is possible in a laboratory, but in the end there is always a clear conclusion, a real decision, and in it there is very little of the element of mere opinion, and no guessing. After the decision as to which solution of the problem will be the best, there comes actual commercialization under engineering direction, and finally the public receives a new product, or a new kind of service, or a better service of an old kind, without any knowledge of how it happened, and with no reference to the names of the engineers responsible for its creation. Thousands of such projects are under way all the time, and this will continue forever.

Public Interest

Public interest in and knowledge of engineering, while yet far less than in the case of law and medicine, is nevertheless on the increase, and there is every reason for more widespread and more precise understanding. Every one has personal contact with the physician at some time, and most people need the lawyer's advice periodically, but no similar direct need exists with regard to engineers. It is true that curiosity is aroused by contact of the public with some of the products of engineering and a mild interest excited, especially if the newspapers take up the matter. A more speedy ship on the transatlantic route, a new canal, an impressive water-power project, a better automobile, a more economical electric lamp, a reduction in the cost of electricity, and a thousand other such evidences of engineering success, may attract attention, but this is not real public interest in engineering.

Real public interest in engineering will come, and with it active public coöperation, with benefits to both the public and the profession, only when there is public understanding that engineering is everybody's business, more or less, and most intimately the business of some who may not as yet have discovered the fact.

There are three broad divisions of proper public interest in engineering: first, the general one of acceptance and utilization of engineering methods, products and engineering services; second, that of investment of funds in enterprises, the soundness of which are primarily matters of engineering determination; and third, that of careers for young men as engineers in the profession.

Considering the first item, that of general use of the productions of engineering. It must be remembered that engineering is fundamentally creative, and that in ever-increasing degree new ideas and methods, new materials, new products, produced from both old and new materials, and better or more economical services are not only being produced regularly and systematically but that this will go on indefinitely in an ever-increasing degree. This is surely a matter of interest to everybody as possible consumers, but it is of especial interest to business men in every line of business, because trade conditions must necessarily change in consequence. Rather more important than this, as affecting the life, security, and prosperity of the whole people, is the understanding of the engineering method, which is the broadening of scientific method to include economics, and then the adoption of this engineering method in all walks of life, in all sorts of affairs of business, and, especially, in matters of public relations and of government. This means, in effect, the elimination of untested mere opinion, of prejudice and mere tradition, of self-interest against general welfare and the substitution of facts and established principles, the substitution of that which is right and best, impersonally selected, impartially judged, and accepted only on proof of validity after survival over every known test.

The second rational basis for public interest in engineering is one of investment. This is especially important in countries where living conditions have advanced, as they have in the United States, to the point where it is possible for so large a part of the population to save some money from income, the surplus over living necessities being available for investment. It is, however, also important in other countries where correction of backward conditions may become possible by the adoption of similar methods, because the methods resulting in funds available for investment are the very methods that produce income for investments. Most of the important enterprises of the time, even those that superficially might seem to be mere exchange or trading affairs with none of the elements of creation of wealth in them, may in fact be founded on engineering, with values that have been increased by engineering. In many cases engineering has created a wholly new thing of real value, and so has actually produced wealth. No such undertaking is possible without capital, and the collection of capital through banks involves personal investments. The soundness of such activities as investments is a matter of engineering determination, subject, of course, to the usual reasonable safeguards of all business, classifiable as good management. It must therefore be recognized that engineering creates new investment opportunities that are natural consequences of the engineering method of creating wealth, not by robbing something to get something, but by true creation.

Finally, engineering as a career must be a matter of interest to the whole public concerned with the problem of most useful employment of its young men as a sociologic as well as an economic question, and especially is this the case with the parents of boys and the boys themselves. There is no more promising career conceivable today than that which engineering offers a young man of the right type. Everywhere, in every walk of life, are young men with the will to work, especially at jobs that are interesting and free of monotony, young men with the creative instinct, an inborn desire to make something. This is the same feeling that prompts the artist, the sculptor, the musician, the writer, the carpenter and the machinist, the tailor or the builder, the true business man and banker with pride in the business and its usefulness, rather than the profits that may be squeezed out of it, and fortunately this is the case with most that succeed. Every young man who feels that he would like to really do things, and there are many who would if only they were told the story of things to be done, is a possible recruit for the engineering army, and for him engineering is a possible career. There must, of course, be sufficient mental capacity to stand the test of training, to grasp the laws of nature that must be learned as part of the training, and to later on learn to play the game of solving the problems that are engineering as a sport where the game is the thing; a most absorbing, clean, satisfying and unselfish game, the game of making nature work for man as man works for himself and his fellow-man, the finest and greatest game in the world—engineering.

Hell Gate Improvement Fifty Years Ago

On September 24, 1876, the great obstruction to ship navigation between New York and the Atlantic, Hallett's Point Reef, was removed by explosion under direction of General John Newton, who had been assigned the duty of examining the obstruction and preparing plans and estimates for the necessary work. Preparatory work of excavating had been going on intermittently since 1869, when Congress made the first appropriation for the purpose. By the explosion 47,461 cubic yards of rock were removed, 52,781 lb. of dynamite and other explosives being fired simultaneously from 96 batteries containing 960 cells. The explosion was entirely successful; no damage of any kind was reported, nor was the navigation interrupted; but the general was accused of moral turpitude for having undertaken the task on a Sunday, which, however, was purely accidental. Over 100,000 sq. ft. of rock ten feet in thickness were lifted, rent, and dropped into the mines beneath, the water over the entire extent of the ground rising in a beautiful white sheet to a height of about 50 ft., and some rocks to about 75 ft. Water 12 to 15 ft. in depth replaced rocks previously exposed at low tide, and after cleaning away the shattered material gave a depth of 26 ft.

The splendid success of this explosion was justly looked upon as a thorough and practical demonstration of the accuracy with which science can weigh forces, and direct and proportion them to the work to be accomplished, and as a fitting tribute to the engineer through whom this application of scientific truths was made.

A full account of this interesting occurrence is given in the *Scientific American* of Sept. 30, 1876, pp. 214–216, *Engineering and Mining Journal* of Sept. 30, 1876, pp. 214–216 and in *Engineering News* of Sept. 30, 1876, pp. 314–315 with detail map; also a short summary in *Journal of the Franklin Institute* of October, 1876, pp. 224–225.

FIG. 1 MAP SHOWING LOCATION OF ROUTES GIVEN IN TABLE 1

C.A.	Colorado Airways, Inc.	F.M.C.	Ford Motor Co.	N.O.A.	New Orleans Airline	VARNEY	W. C. Varney
C.A.T.	Colonial Air Transport, Inc.	HUB	Edward Hubbard	P.A.T.	Pacific Air Transport, Inc.	W.A.E.	Western Air Express
C.D.	Charles Dickinson	K.L.C.A.	Key Largo City Airline	R.A.	Ryan Airlines, Inc.	C.B.	Clifford Ball
F.A.C.	Florida Airways Corp.	N.A.T.	National Air Transport, Inc.	R.A.C.	Robertson Aircraft Corp.	S.A.S.	Stout Air Services, Inc.
		P.R.T.	Philadelphia Rapid Transit Co.	U.S.M.	U.S.P.O. Air Mail Service		

Civil Aviation in the United States

BY ARCHIBALD BLACK,[1] GARDEN CITY, N. Y.

The author traces the beginning of American civil aviation to the establishment in 1918 of the Post Office Air Mail Route between New York City and Washington, D. C., and the subsequent organization of the transcontinental airway. The wonderful success of the Air Mail Service, the entrance of the Ford Motor Company into air-transport operation, and the passage of the Federal law authorizing the carriage of air mail by private operators have given a great impetus to American services. The most careful estimates indicate that the flying mileage on regular American air routes will, in the ensuing year, far surpass that of Great Britain and France. The United States now leads also in "aerial taxi" business and such industrial activities as aerial photography and surveying, and the poison-spraying of insects from the air.

CIVIL aviation in the United States may be said to have started with the establishment of the U. S. Air Mail Service by the Post Office Department in 1918. Actually, there were some civilian activities years before that time, but these were in the nature of exhibition flying and "joy rides," rather than operation for transport or other business purposes. The first air-mail route operating on a regular schedule was established experimentally between New York City and Washington, D. C., but was discontinued some time after the inauguration of the transcontinental service. For several years after the close of the World War, America maintained her standing in civil aviation among other nations mainly through the operations of this Air Mail Service and through the "aerial taxi" operators. We had only two scheduled passenger services, a fact often seized upon by the misinformed in an effort to prove that the United States was hopelessly behind in commercial aviation. This conception of our backwardness is not borne out by the figures now available.

Estimates of Flying Mileage

In the absence of Government regulation (now about to be put into effect) it has been necessary to depend upon private compilations of the mileage flown in the United States. Of the various compilations, those of the Aeronautical Chamber of Commerce are regarded as the most authentic, and these probably err on the low side. It is therefore interesting to note that these estimates, added to the official mileage of the Air Mail Service, have placed the United States well ahead of any European country for the past few years. We did lag behind in the operation of privately owned regular air routes, but through the sudden expansion of the past twelve months our position in this regard has been immeasurably improved. Most of the new operating companies have not yet completed a full year, but it is possible to estimate their annual mileage in advance, basing this upon their mail schedules and making due allowance for interruption through weather or other cause.

European Nations Behind Us in Aviation

In Table 1 the foregoing estimates are presented in detail, together with general data on the various operators. Fig. 1 is a map of the United States, showing the location of the routes given in Table 1 and illustrating the manner in which the country is covered.

[1] Consulting Air Transport Engineer. Mem. A.S.M.E.

Presented before a joint meeting of The American Society of Mechanical Engineers, Aero Club of Pennsylvania, and the Engineers' Club of Philadelphia, Philadelphia, September 7, 1926.

TABLE 1 SCHEDULED AIR-TRANSPORT OPERATORS IN THE UNITED STATES

Name	Contract Air Mail No.	Route	One-way miles	Annual mileage (estimated)	Started
Colonial Air Transport Inc.	1	Boston–Hartford–New York	225	135,000	July 1, 1926
Robertson Aircraft Corpn.	2	Chicago–Springfield–Peoria–St. Louis	278	156,000	Apr. 15, 1926
National Air Transport Inc.	3	Chicago–Moline–St. Joseph–Kansas City–Wichita–Oklahoma City–Ft. Worth and Dallas	1000	736,000	May 12, 1926
Western Air Express Inc.	4	Salt Lake City–Las Vegas–Los Angeles	650	455,000	Apr. 17, 1926
W. T. Varney	5	Elko–Boise–Pasco	435	130,500	Apr. 6, 1926
Ford Motor Co.	6	Detroit–Cleveland	91	54,353	Apr. 13, 1925
Ford Motor Co.	7	Detroit–Chicago	237	161,925	June 1, 1926
Pacific Air Transport Inc.	8	Seattle–Portland–Medford–Sacramento–San Francisco–Fresno–Bakersfield–Los Angeles	1121	672,600	
Chas. Dickinson	9	Chicago–Milwaukee–LaCrosse–St. Paul–Minneapolis	377	263,900	June 7, 1926
Florida Airways Corpn.	10	Atlanta–Jacksonville–Tampa–Ft. Meyers–Miami	683	409,800	Apr. 1, 1926
Clifford Ball	11	Cleveland–Pittsburgh	120	72,000	
Colorado Airways Inc.	12	Cheyenne–Denver–Colorado Springs–Pueblo	199	119,400	May 31, 1926
Philadelphia Rapid Transit Air Service	13	Philadelphia–Washington	120*	168,000	July 16, 1926
Stout Air Services Inc.		Detroit–Grand Rapids	142*	85,200	July 31, 1926
Ryan Airlines Inc.		Los Angeles–San Diego	120*	119,225	Mar. 1, 1925
New Orleans Airline	Foreign mail	New Orleans–Pilottown	80	23,000	Apr. 9, 1923
Edward Hubbard	Foreign mail	Seattle–Victoria (B. C.)	84	20,000	Oct. 15, 1920
U. S. Air Mail Service	U.S.M.	New York–(New Br.)–Cleveland–Chicago	726	363,000	July 1, 1925
U. S. Air Mail Service	U.S.M.	New York–Cleveland–Chicago–Omaha–Cheyenne–Salt Lake City–Elko–San Francisco (etc.)	2669	1,782,400	Sept. 8, 1920 (last leg)
Key Largo City Airline		Miami–Key Largo City	50	8,200	Dec. 15, 1925
Robt. S. Fogg	R.F.D.	Around Lake Winnipesaukee (R. F. D. Route)	43	10,350	Aug. 1, 1925
		Totals	9,450	5,945,853	

*Estimated.

It should be clearly understood that the table and map include none of the "air taxi" or non-scheduled services, of which more will be said later. The total of the estimates, given at the bottom of the table, is very significant when compared with European operations. By taking the latest available figures for European activities and making due allowance for normal expansion, it becomes possible to project these into next year for comparison with our existing operations. Fig. 2 presents this information graphically, only the leading nations being included. German figures have been omitted intentionally, because of the recent reorganization and some consequent uncertainty about the mileage to be covered under the new plans. The German mileage probably will run somewhere between the British and the French. It is very evident from this comparison that European air transport is now far behind that of the United States in total flying mileage. If any one organization were to be singled out as responsible for the tremendous jump in American air transport, that organization would be the Ford Motor Company. Yet this credit would have been earned not so much by its actual work, which has been constructive in itself, as by the fact that the participation of this company in aviation has been interpreted by the general public as indicative of its commercial value.

Ford Activities

For several years the Fords had been interested in aviation, but this knowledge was confined to a group in the aircraft industry and did not reach the public until last year. Early in 1925 the Ford Motor Company began operation of its Detroit-Cleveland and then its Detroit-Chicago air routes. The magic of the name "Ford" carried unusual weight and the public suddenly began to show increased appreciation of the possibilities of the airplane, announcements of important air-transport plans following each other in rapid succession. The timely passage of a Federal law authorizing the Postmaster General to contract for carriage of domestic mail by air also greatly aided this development. Within the past several months these new firms have been putting their plans into operation. The first of the new routes under the air-mail contracts, that of the Florida Airways Corporation, went into operation on April 1, 1926. At the time of writing, all but two of the routes shown on Fig. 1 are in actual operation.

Types of Engines Being Used

It is pleasing to be able to record that all of the equipment in use on our airways is of domestic construction. The 400-hp. Liberty engine proved more versatile than its designers had anticipated, and is now the standard power plant of most of the larger commercial airplanes to date, although present indications point to its early displacement by more modern types of engines. For the smaller airplanes, such as have been used for "aerial taxi" services, the 90-hp. Curtiss OX engine has been used almost universally until recently. It was with this engine that most of the non-scheduled operators built up their reputations. Gradually the newer and post-war types of engines are coming into use, and such models as the Wright "Whirlwind" and the later Curtiss, Packards, and others are finding their way into service. Recently there has been a marked drift toward the air-cooled type, at least in the sizes of less than 500 hp. While the choice of engines has in the past been influenced largely by the availability of war-surplus material, popularity of the newer models is increasing. It is worthy of mention that no foreign engine has been able to hold its own against the domestic product.

Types of Airplanes Being Used

The first civil operations after the war were started with war-surplus Navy flying boats, Army DH-4s and Curtiss JN-4 airplanes.

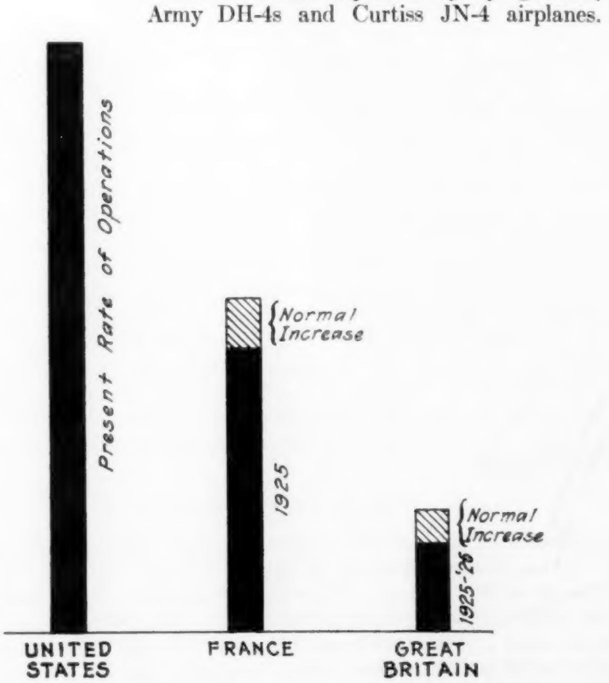


Fig. 2 Annual Mileage of Air-Transport Routes as Indicated for Year 1926–1927

The first-mentioned were used in the early operations of Aeromarine Airways, the second by the U. S. Air Mail Service, and the last were used largely by the operators of "aerial taxi" services. It should, of course, be noted that radical alterations were usually made in order to convert these types to civil use. The war-surplus types are being replaced by more recent and better designs and in a short time will have completely disappeared. Operations are now being carried on with such modern planes as the Douglas Transport; American Fokker; Curtiss "Lark" and "Carrier Pigeon;" Waco; Swallow; Buhl-Verville Airster, etc. As the field of civil aviation grew, distinctions between the various applications be-

came clearer, and these distinctions were reflected in the design of the later airplanes. No operator would today think of purchasing an airplane without first determining which make and model was best suited to his purpose. The make best suited for one purpose is frequently a complete misfit if applied to some other use. The various manufacturers have come to appreciate this, and many of them now confine their productive efforts to satisfying only one class of service. This condition is somewhat analogous to the manufacture of passenger cars, trucks, and buses in the automobile field.

Airways Lighting Development

In the development of airways, remarkable progress has been made in the United States. The Air Service has been steadily surveying air routes and making the information available to the civilian flier, while the Navy has been similarly recording and publishing information on flying facilities along the coast lines. Under the able direction of Col. Paul Henderson (now general manager of National Air Transport, Inc.), the Air Mail Service a few years ago took up the problem of developing night-flying equipment for civil purposes. The interest of several manufacturers of lighting equipment was enlisted and many experiments carried out. These resulted in a decision to operate by night over part of the transcontinental route, and the lighting of this airway was carried out from Chicago, Ill., west to about Cheyenne, Wyo. Once the practicability of night operation on schedule had been demonstrated, Colonel Henderson proceeded to arrange for lighting of the route between New York City and Chicago. This work was completed and overnight service between these cities was started on July 1, 1925. The whole aviation industry owes a debt of gratitude to Colonel Henderson for his work in pushing the development of lighting equipment for these routes.

Performance on the New Routes

In the matter of performance the new air mail and other operators have made an excellent showing. The Florida Airways Corporation, flying over a route previously uncharted, has maintained an operating efficiency of 97 per cent to date. Western Air Express, flying 1300 miles daily, has been running from April 17 to the date of writing without even a forced landing. The Ford Motor Company has been running for several weeks without interruption of schedule, making three round trips daily with only two airplanes, the reserve craft having remained idle meanwhile. The Robertson Aircraft Corporation made 219 single trips out of a possible 220, the one missed being caused by a severe storm forcing a landing, and in this case the mail was forwarded the remaining few miles by rail. W. T. Varney's pilots flew about 75,000 miles with only one forced landing. National Air Transport, operating about 2000 miles daily through a portion of the area subject to cyclonic storms, showed an average of 97 per cent arrivals on time for its first three months. Losses of airplanes through accidental damage have been extremely rare.

"Aerial Taxi" Operations

Parallel to the development of organized and scheduled transport, but somewhat ahead of it, an important business has been created in this country in the hire of airplanes. This branch of aviation has never been given a thoroughly satisfactory name. Sometimes it is referred to as "aerial service" and at other times as the "aerial taxi" business. After the close of the war it was started through the desire of the public to experience the novelty of an airplane ride. As the novelty wore off, other uses began to appear for the service, and it gradually shifted from the basis of "joy-rides" to the more stable one of rendering a special class of transportation to those requiring it. The estimates of the Aeronautical Chamber of Commerce for 1925 showed some 290 operators engaged in this service. Deducting the distance flown by some of these in scheduled service but including mileage flown in aerial photographing and cotton dusting, the remaining distance totals some 5,007,819 airplane-miles in 1925. In the nearest corresponding period British operators in the same class flew only 139,000 airplane-miles.

Photography, Cotton Dusting, and Advertising

One of the divisions of aviation which has been developed on a thoroughly substantial basis is that of aerial photography and aerial surveying. Starting as somewhat of a by-product of aviation, this business has developed into one of its most important branches. Aerial maps and photographs have become accepted in the general business world as filling an extremely useful purpose. Originally conceived for military use during the war, the aerial map has since come into its own. Few cities today find it practicable to get along without an aerial map; railroads and power companies make an aerial survey the basis of their first right-of-way studies; manufacturing firms use oblique aerial photographs to show the extent of their plants, and real-estate operators make use of this type of photograph in their sales work.

Insecticide spraying from airplanes was first tried experimentally a few years ago by the U. S. Air Service in conjunction with the Department of Agriculture. Since then this work has been taken up by private capital, and the spraying of cotton fields has been developed upon a business basis. Efforts are now being made to extend the method to other branches of agriculture.

Aerial advertising is still another phase of aviation which is being developed, and this may, in the future, become of considerably more importance than it is now. As yet its possibilities seem only to have been scratched, the most successful application being "sky-writing." In this system advertisements are written in the sky by means of smoke discharged from an airplane.

On the whole, civil aviation in the United States has little to be ashamed of and much to be proud of. In a world of subsidies it has much more than held its own, and with but little artificial stimulus. Indeed, the *only* artificial stimulus has been the operation of the Government Air Mail Service. For several years past American aviation has maintained its mileage with that of any other nation—foreign propaganda notwithstanding. With this year's tremendous increase in our scheduled services, our mileage will rise to a point where no amount of propaganda can hide the fact that the United States leads the world in aviation.

The Machinery Market in Spain

In a Commerce Report upon the condition of the machinery market in Spain, issued by the Industrial Machinery Division, Department of Commerce, under date of September 27, 1926, attention is called to an interesting development which is affecting the sale of American machine-shop equipment in Spain.

After calling attention to a radical decline of machine-tool imports into Spain during 1925, mention is made of the activities of Manufactureras Femu, S. A. This concern is located at Palma de Majorca in the Balearic Islands and was established about two years ago for the manufacture of drills, taps, cutters, reamers, and similar equipment.

American manufacturers formerly enjoyed a good share of this business, but it is now reported that the bulk of the domestic business is now going to this new concern, which has sufficient capacity to meet the entire Spanish demand.

All of the government and railroad business has been given to this company. Other subsidized industries and those operating under partial state control must give a ten per cent differential to the output of this factory, and import duties have also been raised so that it is difficult for foreign manufacturers to compete in this line.

As matters now stand, of the total machine-tool imports into Spain, Germany supplied 41 per cent, Great Britain 34 per cent, France 11 per cent, and the United States only 5 per cent. It is revealed that since 1924 Germany has advanced to the dominant position, as in that year Great Britain supplied 63 per cent and Germany only 12 per cent. Great Britain still supplies the bulk of the heavy machine tools to Spain, having furnished 58 per cent of those weighing more than 10,000 kg. against 27 per cent from Germany during 1925. Germany's greatest gains have been in machines weighing up to 500 kg., and in this class milling machines appear to predominate.

It is interesting to notice that the report states that the plant of Manufactureras Femu, S. A., is itself largely equipped with American machine tools. (Comments based upon September 27 Report on Spanish Machinery Market issued by Industrial Machinery Division, Department of Commerce.)

Preliminary Power Rating and Tractive Force of Modern Locomotives

Determination of Service Requirements as to Tractive Force at Low and High Speeds for Use in Designing, and a Survey of the General Limitations Governing for the Various Types of Locomotives in Ordinary Service

By R. EKSERGIAN,[1] PHILADELPHIA, PA.

THE adaptation of types and proportions of locomotives to a particular service, and the frequent interest in the substitution of new types of power, such as electric, Diesel, turbine, etc., locomotives, for ordinary steam power, make it important to consider the essential characteristics of locomotive performance in as broadly general a manner as possible.

Weight and clearance limitations, together with the ever-increasing hauling tonnage per unit locomotive, reduce the locomotive problem essentially to one of obtaining the maximum power per unit with large initial tractive force or torque. Thus weight efficiency, which ultimately represents the maximum hauling capacity of a locomotive limited by the fixed weight limitations of the roadway, bridges, etc., is a basic criterion of locomotive performance. Drastic efforts to increase thermal efficiencies are not likely to be very effective in locomotive design unless they react in increased weight efficiency.

Locomotive-Performance Ranges

Locomotive performance may be divided into two ranges: (1) the adhesive range, wherein the maximum tractive force depends only upon the adhesive weight on the drivers, and (2) the power range, which depends upon the operation of a locomotive as a power plant. The power range first determines the limit of the adhesive range, that is, the greatest speed wherein maximum tractive force can be attained; and secondly determines the variation of tractive force at the higher speeds. We are thus concerned in mechanically designing a mechanism that can transmit large torque loadings at low speeds and then proportioning a minimum-weight power plant to give the maximum tractive force at the higher speeds for a given axle, as well as total weight of the locomotive.

Thus the basic specification of a locomotive design is that of ascertaining the service requirements as to initial maximum tractive force required at low speeds, and then the tractive-force requirements at the higher speeds. It is the object of this paper to point out in an approximate way the general limitations in meeting these requirements for the various types of locomotives used in ordinary service.

Locomotive-performance requirements may be briefly classified into (1) road service, (2) yard or switcher service, and (3) industrial and the various special services in which locomotives are used. Road locomotives may be subdivided again into passenger and freight types. It is easy to appreciate apart from the initial tractive-force requirements that power capacity is of major importance in road service. Moreover, the greater maximum tractive force required for freight service implies a greater percentage of adhesive weight over that found in passenger service. In switcher or yard service we are mainly concerned with occasional large tractive forces usually exerted at low speeds. Therefore a quick falling off of the tractive force at the higher speed is relatively of no importance, and the power requirements of this service are thus greatly reduced. Ordinary industrial service is akin to that of yard or switcher service.

Maximum Tractive Force

At very low speeds the power capacity of any locomotive will permit enormous tractive forces to be developed, so that the real limitation of the maximum tractive force is the adhesion weight on the drivers.

[1] Engineer, The Baldwin Locomotive Works. Mem. A.S.M.E.

Presented at a meeting of the Oregon Section of The American Society of Mechanical Engineers, Portland, Ore., May 22, 1926.

The cylinders of a two-cylinder locomotive develop a mean tractive force per revolution given by the formula

$$Z = \frac{Cpd^2S}{D}$$

where Z = mean tractive force per revolution of drivers, lb.
p = boiler pressure, lb. per sq. in.
d = diameter of cylinder, in.
S = stroke, in.
D = diameter of driver, in.
C = card factor.

The factor C takes care of the drop from boiler pressure and the mean effective pressure at the late cut-off. Sometimes C includes the loss due to machine friction, but this is usually separately allowed for in estimating the resistances.

For any multi-cylinder type with n simple-expansion cylinders, the tractive force is obviously

$$Z = \frac{n}{2} \times \frac{Cpd^2S}{D}$$

In compound cylinders it is necessary to approximate the receiver pressure. For equal work in two-cylinder compounds it is evident that since

$$(p - p_m)\, A_h = p_m\, A_L$$

the receiver pressure will be

$$p_m = \frac{p}{R+1}$$

where p = boiler pressure, lb. per sq. in.
p_m = receiver pressure, lb. per sq. in.
A_h = area of high-pressure cylinder, sq. in.
A_L = area of low-pressure cylinder, sq. in., and
$R = A_L/A_h$ = expansion ratio.

and therefore the tractive force is

$$Z = C\,\frac{4p_mA_LS}{\pi D} = C\left(\frac{p}{R+1}\right)\frac{d_L^2S}{D}$$

and for Mallet locomotives, with two groups of cylinders,

$$Z = C\left(\frac{2p}{R+1}\right)\frac{d_L^2S}{D}$$

when as before the factor C is introduced for approximating the actual card area at late cut-off.

In the three-cylinder compound, a type now being experimented upon by The Baldwin Locomotive Works, the receiver pressure is obtained from the relation

$$(p - p_m)\, A_h = p_mA_L$$

But since

$$R = \frac{2\,A_L}{A_h} = \frac{2\,d_L^2}{d_h^2}$$

$$p_m = \frac{2p}{R+2}$$

therefore the tractive force is

$$Z = C\,\frac{6\,p_mA_LS}{\pi D} = C\left(\frac{3p}{R+2}\right)\frac{d_L^2S}{D}$$

This condition for equal work per cylinder, however, requires in the three-cylinder compound a low ratio R approximating 2. Higher ratios for equal work would require impractical early cut-offs on the low-pressure cylinders. Therefore unequal work must be accepted as inevitable when R approximates values used in cross-compounds or ordinary Mallet compounds. The tractive force in such cases can be boosted by bleeding in live steam to the receiver, with its corresponding throttling loss, thus increasing the tractive force on the low-pressure cylinders during the starting period. The estimation of tractive force is then obtained from a detail study of the cards.

The cylinder tractive force for all types of locomotives may be reduced to the expressions found in Table 1.

TABLE 1 FORMULAS FOR CYLINDER TRACTIVE FORCE AND CYLINDER DIAMETERS

SIMPLE LOCOMOTIVES

$$Z = C\left(\frac{pd^2S}{D}\right); \quad d = \sqrt{\frac{ZD}{CpS}} \quad \text{(two-cylinder)}$$

$$Z = C\left(\frac{1.5\,pd^2S}{D}\right); \quad d = \sqrt{\frac{ZD}{1.5\,CpS}} \quad \text{(three-cylinder)}$$

$$Z = C\left(\frac{2\,pd^2S}{D}\right); \quad d = \sqrt{\frac{ZD}{2\,CpS}} \quad \text{(simple Mallet)}$$

COMPOUND LOCOMOTIVES

$$Z_c = C\left(\frac{p\,d_L{}^2S}{D(R+1)}\right); \quad d_L = \sqrt{\frac{ZD\,(R+1)}{CpS}}; \quad d_h = \frac{d_L}{\sqrt{R}} \quad \text{(cross-compound)}$$

$$Z_c = C\left(\frac{2p\,d_L{}^2S}{D\,(R+1)}\right); \quad d_L = \sqrt{\frac{Z_cD(R+1)}{2\,CpS}}; \quad d_h = \frac{d_L}{\sqrt{R}} \quad \text{(Mallet compound)}$$

$$Z_c = C\left(\frac{3\,p\,d_L{}^2S}{D(R+2)}\right); \quad d_L = \sqrt{\frac{Z_cD\,(R+2)}{3\,CpS}}; \quad d_h = d_L\frac{2}{\sqrt{R}} \quad \text{(three-cylinder compound)}$$

The card factor C is taken between 0.8 to 0.9 in the ordinary cut-off operation of locomotives in the development of maximum tractive force. If machine friction is included a lower value should be used, and if taken separately, a higher value.

DRIVING TORQUE

The turning moment exerted by the driving mechanism on the drivers may be termed the driving torque. The total driving torque is resisted by the moment of the adhesive or friction force exerted in a tangential direction at the base of the drivers or rail. This latter is the external force required to overcome the resistance and accelerate the locomotive and train. With the ordinary reciprocating locomotive the driving torque is applied by a sliding-bar linkage to the main axle, and by coupling rods to the remaining driving or coupling drivers.

The rotative effect may be calculated with a given indicator card for the various angular positions of the crank, and from it the mean torque estimated. A simpler way and a check on the former is to equate the work of the cylinders to that of the torque exerted. Thus

$$T_m\,2\pi = 2\,nPS$$

where T_m = mean torque, in-lb.
n = number of cylinders
P = piston load, lb. (assumed constant)
S = stroke of piston, in.

Since $S = 2r$, where r is the crank radius in inches, the mean torque for two-cylinder locomotives is

$$T_m = C\,\frac{4}{\pi}\,Pr$$

and for three-cylinder locomotives

$$T_m = C\,\frac{6}{\pi}\,Pr$$

C being the card factor as before.

It can be shown that the maximum torque occurs at the crank angle of 45 deg. for two-cylinder types, and with two cranks at 30 deg. and one at 90 deg., measured with respect to the cylinder line, for three-cylinder locomotives with cranks at 120 deg. This is evident from Figs. 1 and 2. In these $H = P$, and $V = (pr/l)\sin\theta$ (approx.), where l = length of connecting rod, in., and θ = crank angle. Hence referring to Fig. 1, the maximum torque for a two-cylinder locomotive is (assuming constant piston load)

$$T_{max2} = 2\,Hr\sin 45° + 2\,Vr\cos 45°$$

$$= \sqrt{2}\,Pr + 2\,\frac{Pr}{l}\sin 45°\cos 45°$$

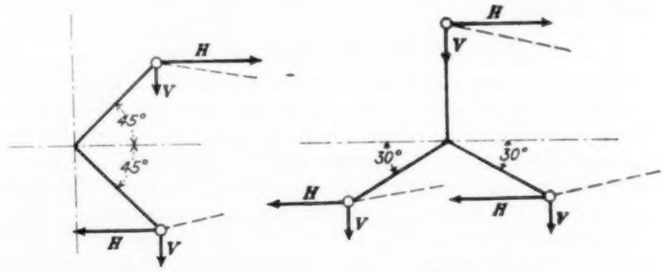
$$= Pr\left(\sqrt{2} + \frac{r}{l}\right)$$

For a three-cylinder type, however, the vertical component due to the obliquity of the connecting rod has no net effect at maximum torque, therefore (Fig. 2)

$$T_{max3} = Pr + 2\,Pr\sin 30° = 2\,Pr$$

Referring again to Fig. 1, it is evident that with early cut-off H_2 is greater than H_1, since the piston load is reduced by a drop in the pressure after cut-off. Therefore the peak torque is reduced by early cut-off in two-cylinder locomotives, and when 50 to 60 per cent cut-offs are used the variation of torque can be made to approach that in three-cylinder locomotives.

Values of l/r in locomotive practice vary from 6 to 8 as shown below, constant piston load being assumed throughout the stroke.



FIGS. 1 AND 2 CRANK ANGLES FOR MAXIMUM TORQUE FOR TWO-CYLINDER AND THREE-CYLINDER LOCOMOTIVES

	Values of l/r					
	0	6	6½	7	7½	8
	Two-Cylinder Locomotives					
T_{max}	1.414 Pr	1.581 Pr	1.568 Pr	1.557 Pr	1.547 Pr	1.539 Pr
T_{mean}	1.273 Pr	1.273 Pr	1.273 Pr	1.273 Pr	1.273 Pr	1.273 Pr
T_{max}/T_{mean}	1.11	1.241	1.230	1.224	1.215	1.210
	Three-Cylinder Locomotives					
T_{max}	2 Pr	2 Pr	2 Pr	2 Pr	2 Pr	2 Pr
T_{mean}	1.91 Pr	1.91 Pr	1.91 Pr	1.91 Pr	1.91 Pr	1.91 Pr
T_{max}/T_{mean}	1.047	1.047	1.047	1.047	1.047	1.047

Even with late cut-off the piston-load variation along the stroke is sufficient to modify the ratios given above, but as a first approximation they may be taken as maximum values that can occur.

ADHESION COEFFICIENTS

The external force at the base of the drivers may be divided into a normal or vertical component and a tangential or horizontal component. The latter is the tractive or propulsive force of the locomotive and is limited by the normal pressure and the maximum coefficient of friction between wheel and rail.

If Z = total tangential component at base of drivers
μ_m = coefficient of friction (max.), and
A = total normal component or adhesive weight on drivers

then

$$Z_{max} \leqq \mu_m\,A$$

where μ_m may be taken at 0.3, and

$$Z_m \leqq \mu_m \cdot A\left(\frac{T_m}{T_{max}}\right)$$

Thus the maximum tractive force limited by the adhesive capacity is dependent upon (1) the total adhesive weight on the

drivers, (2) the maximum coefficient of friction between wheel and rail, and (3) finally on the ratio of maximum to mean torque exerted on the drivers. With a uniform torque we could take advantage of the maximum friction between wheel and rail, while with a large fluctuation in torque such as might occur with a two-cylinder locomotive working at late cut-off and with large connecting-rod obliquity, the mean maximum torque will be reduced considerably.

If Z_m is the actual tractive force exerted by the cylinders, the factor of adhesion is defined as

$$\text{Factor of adhesion} = \frac{A}{Z_m} = \alpha$$

Evidently

$$\frac{A}{Z_m} \geqq \frac{1}{\mu_m} \times \frac{T_{\max}}{T_m}$$

and with $\mu_m = 0.3$, $A/Z_m = 3.33\ T_{\max}/T_m$ is the limiting factor of adhesion.

Thus for a two-cylinder locomotive $A/Z_m = 3.33 \times 1.23 = 4.1$ when $l/r = 6.5$, while for a three-cylinder locomotive $A/Z_m \geqq 3.5$. Thus a three-cylinder locomotive could be counted on for a 17 per cent increase for this particular example. Actually, however, the deviation would ordinarily not be as great, due to the varying piston load along the stroke, etc.

In the two-cylinder locomotive—

$$\frac{T_{\max}}{T_m} = 1.11 \text{ with no connecting-rod obliquity}$$

$$= 1.21 \text{ with connecting-rod obliquity}$$

and to account for a varying load along the stroke that would occur to a more or less extent even with late cut-off,

$$\frac{T_{\max}}{T_m} = 1.19 \text{ is taken as a first approximation.}$$

In the three-cylinder locomotive—

$$\frac{T_{\max}}{T_m} = 1.08 \text{ approximately.}$$

Hence for the same adhesive weight, and assuming an average minimum factor of adhesion of 4.1 for a two-cylinder locomotive,

$$\frac{\text{Peak tractive effort, three-cylinder}}{\text{Peak tractive effort, two-cylinder}} = \frac{Z_3}{Z_2} = \frac{1.19}{1.08} = 1.1$$

If α is the factor of adhesion to be used for a three-cylinder locomotive, then

$$\frac{Z_3}{Z_2} = \frac{A/\alpha}{A/4.1} = 1.1 \therefore \alpha = 3.73$$

Reasoning similarly, the factor of adhesion of an electric locomotive may be safely taken at $\alpha = 3.57$. However, careful consideration must be given to weight transfer, particularly with axle-hung motors, the factor of adhesion being then based on the minimum individual axle load, since the motors are all in series.

Assuming 4.1 as the average limiting factor of adhesion of a two-cylinder locomotive with long cut-off, then for a three-cylinder locomotive $\alpha = 3.7$, while for an electric locomotive $\alpha = 3.5$.

With the cut-off around 50 to 60 per cent, the torque variation of two-cylinder locomotives is reduced, approximating three-cylinder performance. Therefore the factor of adhesion may be reduced to values approximating those possible with three-cylinder types.

POWER RELATIONS

When the steam consumption of the cylinders approaches the maximum evaporative capacity of the boiler at a given speed, the tractive force then becomes dependent upon the evaporative capacity of the boiler. It is important to note that the power is developed in the cylinders by the work of expansion of the steam and that the boiler merely supplies the steam. Therefore such terms as "boiler horsepower" are complete misnomers unless properly qualified. If, however, we define a given rate of steam consumption as developing one horsepower in the cylinders, the evaporative capacity of the boiler may be arbitrarily measured by the unit, and in this sense only may the term "boiler horsepower" be used. Thus boiler horsepower is a measure of the evaporative capacity of a locomotive by the horsepower unit.

With a fixed maximum evaporative capacity of the boiler, the horsepower developed by the locomotive depends upon the cylinder efficiency; that is, upon the rate of steam consumption per horsepower developed. The steam consumption is a function of the cut-off and speed, and at low speeds with late cut-offs is relatively large, which therefore reduces the horsepower that can be developed in the cylinders for a given rate of evaporation from the boiler. Thus at low operating speeds, at the end of the adhesion range approximately only 60 per cent of the maximum horsepower can be developed. The introduction of early cut-off at starting, meeting the reduced mean effective pressure by oversized cylinders, reduces the steam consumption and increases the cylinder efficiency, resulting in increased horsepower capacity at the low operating speeds. On the other hand, if the locomotive designed for operating at early cut-offs at low speeds is also operated at high speeds, to maintain a constant draft on the boiler would result in impractical early cut-offs at the higher speeds together with poor cylinder efficiency, due to excessive condensation losses which accompany very short cut-offs. More important, the peak load on the average piston would in such a case be excessive, resulting in a large increase in the weight of the machinery and poor counterbalance for the higher speeds. Thus such expedients for increasing the horsepower capacity of a locomotive must be given careful consideration in conjunction with the operating zone of performance.

At this point it is important to differentiate between maximum power capacity and thermal economy. The capacity of a locomotive in developing maximum power is dependent upon the maximum evaporative capacity of the boiler. Under these conditions, in a sense, the boiler is being forced, and the percentage of the latent heat transferred to the steam—that is, the boiler efficiency—is at its lowest. In addition the horsepower developed is further dependent upon the cylinder steam consumption per horsepower developed, and thus is dependent upon the particular operating cut-off. It is interesting to note, however, that with cut-offs varying from 30 to 50 per cent the variation in steam consumption per horsepower-hour is very small, and in a first approximation it can be taken as constant. This is mainly due to two counteracting effects; with early cut-off the gain through expansion is offset by the increased loss due to the higher percentage of cooling area in the cylinder walls promoting increased condensation effect, or the lowering of the temperature of superheat at cut-off. Thus when a locomotive is operated on light load and carefully fired for such economical cut-offs, the thermal economy is at its maximum. It is appreciated, however, that in the operation of the locomotive in its particular function as a traction machine, thermal economy is secondary to power capacity as a unit.

The horsepower developed is proportional to the product of the tractive force and speed; that is,

$$H_p = \frac{ZV}{375}$$

where Z = tractive force, and V = speed, m.p.h. The total evaporation per hour of the boiler is proportional to the heating surface H and to the yield per square foot of heating surface q. Evidently this evaporation must be equal to the total steam consumption of the cylinders per hour (neglecting auxiliaries); that is,

$$Hq = H_p h$$

where h = cylinder steam consumption per horsepower-hour. Therefore the horsepower developed can be measured in terms of the evaporation of the boiler Hq and the cylinder steam consumption per horsepower developed h; hence

$$H_p = \frac{ZV}{375} = \frac{Hq}{h}\left(550\ \frac{\text{ft-lb.}}{\text{sec.}}\right)$$

which is the fundamental power equation of the steam locomotive.

The unit rate of evaporation depends upon the draft created by the exhaust blast, which is approximately proportional to the

total steam consumption. The relative proportioning of the various component heating surfaces, firebox volume, etc., and their relations to the grate modify the unit evaporation for a particular boiler. With ordinary proportions, an average maximum evaporation is estimated at from 12 to 13 (lb. per sq. ft.), though higher values are frequently reached on tests. A more careful analysis would consider the component yields of firebox surface, tubes, etc.

The steam consumption per unit horsepower developed in the cylinder is a function of the cut-off ϵ and the speed V; that is,

$$h = f(\epsilon, V)$$

With long cut-offs occurring in low-speed operation the steam consumption may reach values of from 27 to 33 lb. per hp-hr. developed, while at early cut-offs the steam is reduced to from 18 to 20 lb. per hp-hr. in the average superheated locomotive.

Thus the horsepower is a function of the speed since the cut-off is a function of the speed. Since

$$H_p = H\frac{q}{h} = H\frac{q}{f(\epsilon, V)}$$

it is evident that the horsepower variation against speed can be determined provided we know the variation of the ratio.

In the actual performance of a locomotive the cut-off must be so adjusted as to give a mean effective pressure consistent with the evaporative capacity and steam consumption of the locomotive for the particular cut-off. Now the steam consumption per horsepower as previously noted is a function of the cut-off and the particular speed at which this cut-off is operated. In general, late or long cut-offs give higher values for the steam consumption h than the earlier or short cut-offs where advantage is taken of the expansion of the steam. At cut-offs below from 20 to 25 per cent the cooling effect of the cylinder walls, which takes place mostly in the clearance space, becomes so marked that it more than counterbalances the gain due to greater expansions, resulting in an actual increase of steam consumption. The principal effect of speed is to wiredraw the card, resulting in a decreased mean effective pressure. The card throttling effect with speed increases with the longer cut-offs. Thus in estimating the steam consumption per horsepower-hour it is necessary not only to base it on the cut-off, but also on the particular speed of operation. The steam consumption is determined primarily by the cut-off, while the mean effective pressure is determined from the card area, which depends upon the operating speed as well as cut-off; thus the steam consumption per horsepower-hour is a function of both speed and cut-off. The total steam consumption determined by the product of steam consumption per horsepower-hour for the particular operating conditions and the horsepower developed in the cylinders, is obviously equal to the total evaporation of the boiler. Thus for a given steam-consumption rate per horsepower-hour the actual horsepower developed becomes fixed by the evaporative capacity of the boiler.

From numerous tests locomotive builders have arrived at the variation of cut-off with speed in the average performance of locomotives, and from this variation a mean-effective-pressure curve has been ascertained as a function of the speed. This curve is taken as the average maximum and as such is conservative, while further tests indicate higher permissible values when provided with greater evaporative capacity. The mean-effective-pressure curve can then be plotted against piston speed or revolutions per minute. It is to be noted, however, that this curve does not discriminate between different types of locomotives wherein greater or less evaporative capacity permits the use of longer or shorter cut-offs than the average cut-off performance, so therefore it is necessary to differentiate this average curve into corrected performance curves adaptable for the different types and consistent with the evaporation capacities of these types.[2] Or, conversely, future tests on different types can be translated into a general average-performance curve so that we can predict the performance of some other type. Since the mean effective pressure times piston speed or revolutions per minute is proportional to horsepower, it is possible to plot the horsepower variation, and therefore the variation of q/h.

The curve shown in Fig. 3 gives the average horsepower variation against piston speed or revolutions per minute in terms of unit horsepower developed at 1000 ft. per min. piston speed or 200 r.p.m. of the drivers. Since

$$\frac{q}{h} = \frac{H_p}{H} = \text{constant} \times H_p$$

the variation of q/h is directly proportional to the variation in the unit-horsepower curve.

If when unit horsepower is developed, that is, if at the rated horsepower taken at 1000 ft. per min. or 200 r.p.m. we take $q = 12$ lb. per sq. ft. per hr. as the maximum average evaporation, and $h = 20$ lb. per hp. per hr. for the cylinder steam consumption, then at unit horsepower

$$\frac{q}{h} = \frac{12}{20} = 0.6$$

Since q/h is proportional to the horsepower variation, we may plot Fig. 4, which gives the variation of $q/h = H_p/H$, that is, the horsepower developed per square foot of heating surface.

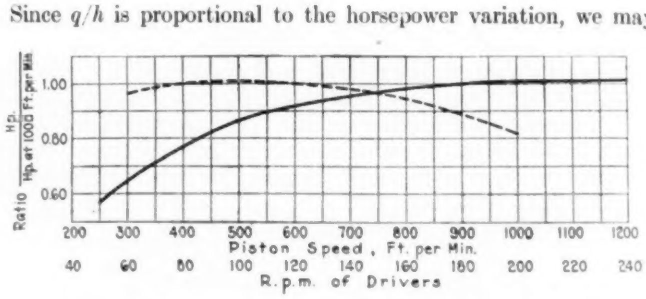


Fig. 3 Average Horsepower Variation with Speed—Superheated Steam

[Solid curve shows variation of horsepower with ordinary late cut-off at starting; dotted curve shows roughly variation with early cut-off (approx. 50 per cent) at starting. Unit hp. taken at 1000 ft. per min. or 200 r.p.m.]

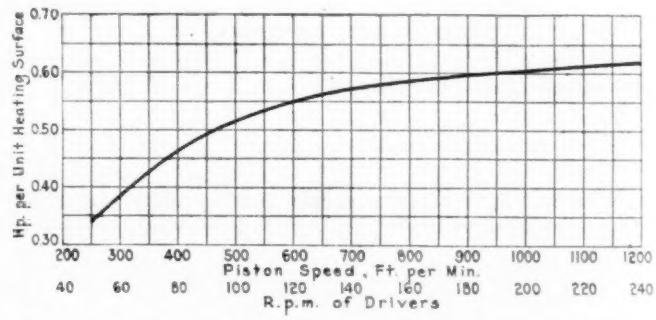


Fig. 4 Average Horsepower Yield per Unit of Heating Surface—Superheated Steam

(For use with ordinary late cut-off at starting.)

The curve of variation of horsepower per square foot of heating surface against speed is at present tentative since considerable further study and tests are needed, so this curve as well as the analysis is offered as a procedure in the performance analysis of a locomotive.

One check at low speeds should be mentioned. With full gear, with partial allowance for clearance volume, we assume the total cylinder displacement per revolution

$$V_c = \frac{4(\pi/4)d^2S}{1728} \text{ (cu. ft.) (2-cyl.)}$$

and if n_a = r.p.m. at maximum speed at full gear, and U_s = specific volume of the steam at cut-off, then the steam consumption per hour is

$$W_h = \frac{\pi d^2 S}{1728} \cdot \frac{N_a 60}{U_s} = \frac{d^2 S N_a}{9.16\, U_s} \text{ (lb. per hr.)}$$

Therefore, equating this to the total evaporation, we have

$$\frac{ASN_a}{9.16\, U_s} = Hq = 12\, H$$

[2] See discussion in later paragraphs on wiredrawing and m.e.p. limitations around full gear.

Therefore

$$N_a = \frac{9.16\,U_s qh}{d^2S} = \frac{110\,U_s h}{d^2S}$$

for the maximum speed at full gear or maximum tractive force, and the corresponding horsepower developed is

$$H_{pa} = \frac{T\,2\pi N_a}{33{,}000}$$

where $T = C(2/\pi)p(S/12)$
$p = (\pi/4)d^2p$
$C = 0.8$ to 0.9

Therefore the steam consumption per horsepower-hour is W_h/H_{pa} and

$$\frac{q}{h} = \frac{12\,H_{pa}}{W_h}$$

Above the speed N_a the tractive force in the power range is obviously

$$Z = 375\,\frac{H}{V}\cdot\frac{q}{h} = 375\,\frac{H}{V}\left[\frac{H_p}{H}\right]$$

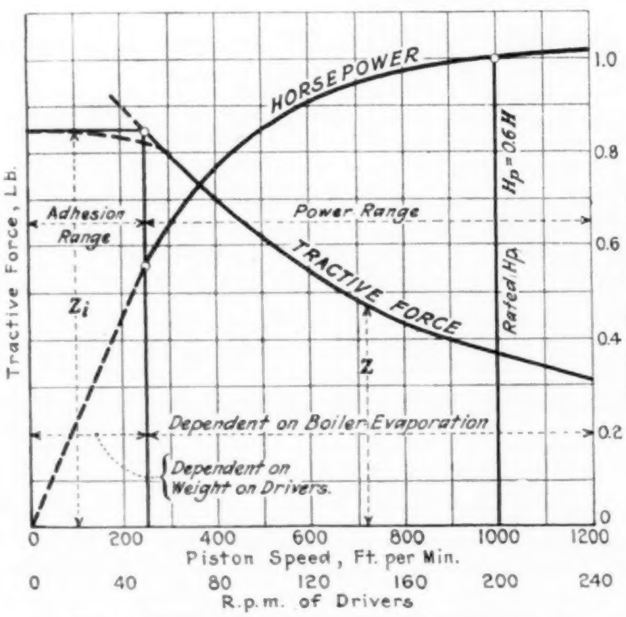


Fig. 5 Power and Tractive-Force Characteristics

and since $Z = xZ_i$, where Z_i is the maximum or initial tractive force,

$$x = \frac{375}{V}\left[\frac{H}{Z}\right]\left[\frac{H_p}{H}\right]$$

Locomotives with a larger ratio of heating surface to maximum tractive force maintain a high percentage of tractive force at speed, and with low ratio of heating surface to initial tractive force fall off quickly in tractive force with speed.

Finally it is important to note that the horsepower yield per square foot of heating surface does not vary greatly with variation of cylinder or driving-wheel dimensions; in other words, the performance of a locomotive at speed is fairly independent of the exact cylinder proportions provided reasonable cylinder efficiency is obtained.

We can now construct the characteristic curves of locomotive performance very simply as shown in Fig. 5.

Horsepower Curve.

$$H_p = H\left(\frac{q}{h}\right) = H\left(\frac{H_p}{H}\right)$$

$$= \text{Heating surface} \times \frac{\text{Horsepower yield}}{\text{Sq. ft. heating surface}}$$

Tractive-Force Curve. At low speeds when dependent upon adhesion—that is, the adhesion range,

$$Z_i = \frac{A}{\alpha} = \mu A$$

where A = adhesion weight on drivers
μ = coefficient of friction
α = factor of adhesion = $1/\mu$.

At the higher speeds after the r.p.m. reaches the value

$$N_a = \frac{110\,U_s\,H}{d^2\,S}$$

where d = diameter of cylinder, in.
S = stroke, in.
N_a = r.p.m.
D = diameter of drivers, in.
V = train speed, miles per hr.
U_s = specific volume of steam at cut-off, cu. ft. per lb.

which is the power range,

$$Z = \frac{375\,H_p}{V} = \frac{126{,}000\,H_p}{ND} = \frac{21{,}000\,H_p}{v_sD/S}$$

Cylinder and Boiler Proportions

Locomotive performance can be shown in terms of the variation of mean effective pressure with piston speed or revolutions per minute of the drivers. The horsepower developed by the cylinders is then estimated from the cylinder dimensions as follows:

If d = diameter of cylinder, in.
S = stroke, in.
v_s = piston speed = $SN/6$, ft. per min.
N = number of revolutions per minute
D = diameter of driver, in.
α = factor of adhesion
H = total heating surface, sq. ft.
h = cylinder steam consumption, lb. per hp-hr.
c = coupling ratio
W = total locomotive weight, lb.
p_m = mean effective pressure, lb. per sq. in.
p_i = initial mean effective pressure at starting, lb. per sq. in.
n = number of equivalent simple cylinders
q = rate of mean evaporation per sq. ft. of heating surface

then for the horsepower developed,

$$H_p = \frac{n\cdot\pi/4\cdot p_m\cdot d^2\cdot 2\cdot S/12\cdot N}{33{,}000}$$

hence, in reducing, in terms of piston speed,

$$H_p = \frac{np_md^2v_s}{42{,}000} = \frac{qH}{h}$$

or in terms of revolutions per minute,

$$H_p = \frac{np_md^2SN}{252{,}000} = \frac{qH}{h}$$

Also

$$p_m = \left\{p\left[\frac{1+\log_e r}{r}\right] - p_b\right\}C$$

where p = boiler pressure, lb. per sq. in.
p_b = nominal back pressure (= 20 lb. per sq. in., approx.)
r = ratio of expansion = cut-off (approx.)
C = card factor (= 0.7 approx. in preliminary calculation).

In the calculation of cylinder proportions for compound locomotives it is customary to refer the mean effective pressure and cylinder proportions to the dimensions of the low-pressure cylinder. Then n refers to the number of compound sets; that is, for cross-compounds $n = 1$; for Mallet compounds, $n = 2$; etc., while d refers to the diameter of the lower-pressure cylinder d_l.

For the mean effective pressure,

$$p_m = \left\{p\left[\frac{1+\log_e Rr_h}{Rr_h}\right] - p_b\right\}C$$

where $R = \frac{d_L^2}{d_h^2} \left(\begin{array}{l} d_L = \text{diameter of low-pressure cylinder, in.} \\ d_h = \text{diameter of high-pressure cylinder, in.} \end{array} \right)$

r_h = ratio of expansion in high-pressure cylinder

C = card factor (= 0.65 approx. in preliminary calculation)

In a three-cylinder compound we have two symmetrical low-pressure cylinders, and therefore the low-pressure volume is $2 \cdot \pi/4 \cdot d_L^2 S$. If p_m is the mean effective pressure referred to the low-pressure volume, then the equivalent cylinder area of the equivalent low-pressure cylinder is $2 \cdot \pi/4 \cdot d_L^2$, while

$$p_m = \left\{ p \left[\frac{1 + \log_e R\, r_h}{R r_h} \right] - p_b \right\} C$$

$$R = \frac{2 d_L^2}{d_h^2}$$

C = card factor (= 0.65 approx.)

and if $d = d_L$, $n = 2$ in the formula for H_p.

For the variation of mean effective pressure with piston speed we have

$$H_p = \frac{n p_m d^2 v_s}{42{,}000} = \frac{qH}{h}$$

but for the initial tractive force at starting,

$$Z_i = \frac{n p_i d^2}{2D/S} = \frac{CW}{\alpha}$$

and if $p_m = x p_i$, then

$$H_p = \frac{x\, CW/\alpha \cdot D/S \cdot v_s}{21{,}000} = \frac{qH}{h}$$

Therefore

$$x = \frac{21{,}000}{v_s} \frac{\alpha}{C\, D/S} \left[\frac{H}{W} \right] \left[\frac{H_p}{H} \right] \text{ in terms of piston speed}$$

$$= \frac{126{,}000}{N} \frac{\alpha}{CD} \left[\frac{H}{W} \right] \left[\frac{H_p}{H} \right] \text{ in terms of r.p.m.}$$

where the mean effective pressure in terms of the initial or starting mean effective pressure is $p_m = x p_i$.

Thus the mean effective pressure varies (1) inversely with the speed, (2) directly as the factor of adhesion, (3) inversely as the coupling ratio, (4) inversely as the wheel-stroke ratio, (5) directly as the horsepower yield per square foot of heating surface, and (6) directly as the weight efficiency; i.e., the heating surface per pound weight of the locomotive.

As previously noted, the horsepower yield per square foot of heating surface is dependent upon the unit evaporation of the boiler and the steam consumption, which latter varies with the cut-off and speed and the condition and method of using of the steam, that is, whether superheated or saturated, compounded or simple, etc. At low speeds and with long cut-offs the steam consumption is large, so therefore the horsepower per square foot of heating surface is considerably less than at the higher speeds where the more economical cut-offs occur.

The ratio H/W or the available heating surface per pound of total weight of the locomotive, is frequently considered constant and as a measure of the efficiency of design independent of the type, etc. If W_b = weight of the boiler, W_m = weight of the machinery, frame, axles, etc., and W_k = weight of trucks and auxiliaries, and if we assume $H = k_b W_b$ (proportional to the weight of boiler) and $W = W_b + W_m + W_k$, we observe that

$$\frac{H}{W} = \frac{k_b}{1 + \left[\frac{W_m + W_k}{W_b} \right]} = \frac{k_b}{1 + \left[\frac{W_m + W_k}{W - (W_m + W_k)} \right]}$$

This equation is of particular interest as it shows that with a fixed limitation on the total weight, with a given weight of machinery and auxiliaries the available boiler weight becomes definitely fixed. So therefore we should expect some variation of H/W for different designs and particular types. The variation of H/W is not great, however, and in a first approximation when used as a preliminary design constant it may be assumed constant.

Usually when large coupling ratios are used as in freight locomotives, the ratio of wheel diameter to stroke is small and the product tends to balance the product of the low coupling ratios found in passenger service with the large wheel-diameter-to-stroke ratio. That is, CD/S tends toward a constant value for a large variety of types of locomotives. A conspicuous exception is in the comparison of a Santa Fe type with a Mikado, where D/S is the same while C increases to its largest value with the Santa Fe type. Obviously the mean effective pressure falls off quicker with speed with a Santa Fe or Consolidation type than with a Mikado type. This is not a deficiency in design, but rather a characteristic of a type.

Finally a locomotive with a low factor of adhesion, that is, an over-cylindered engine, falls off quicker in mean effective pressure against piston speed than does a locomotive with a high factor of adhesion, that is, an under-cylindered locomotive.

Attempts have been made to generalize the performance of a locomotive by setting up a comparison with a simple standard. With speed factors $x = 0.445$ for superheated locomotives and $x = 0.412$ for saturated locomotives at a piston speed $v_s = 1000$ ft. per min., a boiler of 100 per cent capacity has been defined as developing in the cylinders

$$H_p = \frac{2 \times 0.85\, pA \times 0.445 \times 1000}{33{,}000} = 0.0229\, A \text{ for superheated engines}$$

$$= \frac{2 \times 0.85\, pA \times 0.412 \times 1000}{33{,}000} = 0.0212\, A \text{ for saturated engines}$$

The above as previously shown does not take into consideration the factor of adhesion the coupling ratio c and the ratio of wheel diameter to stroke. If, however, we tacitly assume the weight efficiency to be 120 lb. per hp. and the maximum ratio $H_p/H = q/H = 0.6$, then

$$\frac{W}{H} = \left(\frac{W}{H_p} \right) \left(\frac{H_p}{H} \right) = 120 \times 0.6 = 72$$

So the percentage variation in mean effective pressure for a simple two-cylinder superheated locomotive is given by the expression

$$\frac{21{,}000}{1000} \frac{\alpha}{C\, D/S} \frac{0.6}{72} = 0.175 \frac{\alpha}{C\, D/S}$$

Using this percentage of the mean effective pressure, we have for a rough approximation for a superheated two-cylinder locomotive

$$H_{p(\max)} = 0.00707 \frac{\alpha}{C\, D/S} p d^2$$

taking $v_s = 1000$ ft. per min., while the horsepower developed at other piston speeds would vary as the ratio $1.66\, q/h$.

The ratio D/S ranges from 2.25 to 1.9 for freight and from 3.15 to 2.5 for passenger locomotives. The lower limit of D/S is evidently governed by wheel-center proportions, clearance of main-rod ends, etc., and its higher limit by clearances with firebox, etc., and allowable length of rigid wheelbase where several drivers are used. With high-speed locomotives limited by piston speed,

$$\frac{D}{S} = \frac{56\, V}{v_s}$$

where V = maximum speed, m.p.h.

v_s = limiting piston speed, ft. per min.

and when $v_s = 1200$ ft. per min. for the average maximum speed,

$$\frac{D}{S} = 0.0467\, V$$

This shows that with the driver diameter limited by wheelbase, clearances, etc., short-stroke cylinders are necessary for high-speed performance.

In heavy freight service high initial tractive force is required, hence D/S must be made as small as possible with lower piston speeds, while in passenger service the lower initial tractive force makes it possible to use higher values of D/S to the limiting of

piston speeds as given above. The lowest value of D/S for freight service is seldom below 2.0.

It is equally profitable to consider this variation against r.p.m., since small locomotives for special service seldom run to piston speeds found in the road locomotives considered above. The real criterion is then their limiting r.p.m. and the variation of mean effective pressure against r.p.m.

Further Boiler Proportions

Let us now briefly consider the essential characteristics of boiler performance. In stationary practice we find considerable variation in heating surface and grate proportions with resulting good efficiencies; so therefore the yield per unit of evaporative surface varies for the different types, and the total heating surface for such types is not a criterion of the evaporative capacity of the boiler. The locomotive boiler due to constructive limitations follows a common type with common proportions of grate, etc., to heating surface, and therefore the heating surface in a first approximation measures the evaporative capacity of the boiler.

Much credit for pioneer work in analyzing the characteristics of boiler performance must be given to Mr. Lawford E. Fry. Mr. Fry's work is based on the fundamental assumption that boiler efficiency is a linear function of the rate of firing. This assumption is completely justified from the test results on the Altoona Test Plant of the Pennsylvania Railroad. From this assumption it can be readily shown that the total evaporation is a quadratic function of the rate of firing, and therefore we should expect a maximum evaporation to be reached at a given rate of firing. Since the efficiency decreases with increased rate of firing, it is evident that as far as good boiler performance is concerned, the locomotive cannot be forced with economy. It can thus be appreciated that it is especially important for road locomotives to use as large a boiler as possible. This of course is limited by the weight allowance for the boiler; that is, allowable weight of locomotive minus weight of machinery, trucks, and auxiliaries. It is also seen that a very interesting condition justifies the cutting out of certain auxiliaries when the gain in boiler efficiency due to the weight allowance of the auxiliary compensates the particular thermal saving of the auxiliary. This is particularly true when a locomotive must be forced to its maximum capacity.

The efficiency E_b of a boiler is found to vary as a linear function of the rate of firing; that is, if x = coal consumption per hour per sq. ft. of grate surface,

$$E_b = \frac{C - mx}{100} \text{ per cent}$$

where C = 75 to 85 and m = 0.20 to 0.30.

If Q = total evaporation, lb. per hr.

Φ = total heat of steam including that for superheating, B.t.u.

A_g = effective grate area, sq. ft.

$(\text{B.t.u.})_c$ = heat value of the coal in B.t.u.

then

$$A_g x(\text{B.t.u.})_c E_b = \Phi Q$$

and the total evaporation Q for a given rate of firing x is

$$Q = \left[\frac{A_g(\text{B.t.u.})_c}{\Phi}\right]\left[\frac{Cx - mx^2}{100}\right] \text{lb. per hr.}$$

While the maximum evaporation occurs when $dQ/dx = 0$, that is, when the rate of firing is $x = C/2m$, the boiler efficiency at this firing rate would be $C/200$, or only around 35 to 40 per cent. Actually the maximum evaporation would occur at a somewhat lowering firing rate than given by the theoretical value, and the efficiency would be very poor indeed.

The maximum evaporation would occur if $C = 75$ and $m = 0.25$ at 150 lb. per sq. ft. coal on the grate. Practice limits the maximum coal consumption to 120 lb. per sq. ft. for efficient maximum horsepower conditions.

Since $Q = Hq$, the unit evaporation is

$$q = \left[\frac{(\text{B.t.u.})_c}{\left[\frac{H}{A_g}\right]\Phi}\right]\left[\frac{Cx - mx^2}{100}\right]$$

and thus the unit evaporation is increased with a large grate, provided a corresponding firebox volume for proper combustion is possible.

Since Φ = total heat of saturated steam $+ C_pT_D$, where T_D = degree of superheat, the unit evaporation is reduced by excess superheating. The degree of superheat should be sufficient to allow for heating the cylinder walls and then leaving a margin over dry saturated steam to prevent any possibility of cylinder condensation. The unit evaporation is dependent upon the heating value of the coal and the efficient proportioning of the boiler dimensions, giving a high value to C and a lower value to m.

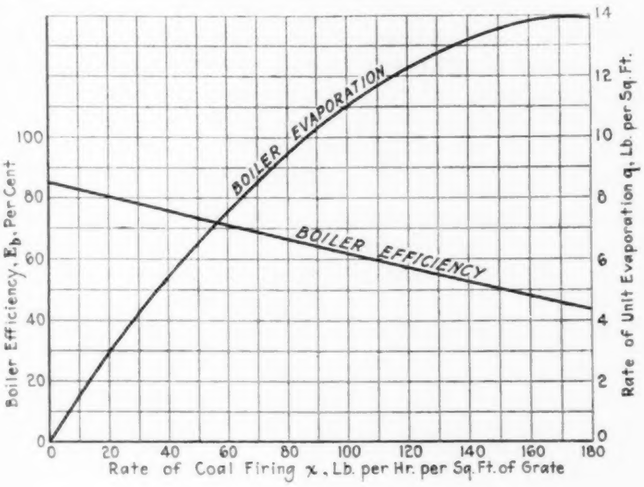


FIG. 6 BOILER CHARACTERISTICS
($C = 85$; $m = 0.233$; $H/A_g = 60$; $(\text{B.t.u.})_c = 14{,}000$.)

If, we assume $(\text{B.t.u.})_c = 14{,}000$; $C = 85$; $m = 0.233$; $T_D = 200°$; $p = 200$ lb. per sq. in., $\Phi = 1307$; $H/A_g = 60$, and $x = 120$; then

$$q = \frac{14{,}000}{60 \times 1307} \times 68.4 = 12.2 \text{ lb. per sq. ft. (See Fig. 9)}$$

which checks with the assumption previously made on unit evaporation.

Cylinder Characteristics

So far we have considered the power capacity of a locomotive and its variation with piston speed and revolutions per minute, and in all cases it is found to be a function of the ratio of the unit rate of evaporation to the cylinder steam consumption per horse-power developed. Therefore any means of reducing the steam consumption has a marked effect in increasing the capacity of the locomotive as well as the overall weight efficiency.

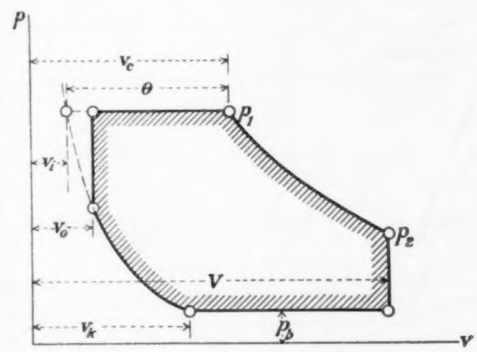


FIG. 7 INDICATOR CARD

In a saturated-steam locomotive, cylinder condensation causes a portion of the steam to condense directly into water, thus increasing the steam consumption estimated from the specific volume of saturated steam from 30 to 50 per cent in an average locomotive; moreover it leaves the steam at cut-off with a considerable degree of wetness. The reëvaporation of the wet steam causes the expansion curve to follow the law pv = constant. The expansion curve is not an isothermal one, and it is merely a coincidence that the process of reëvaporation makes it approach the curve for an isothermal expansion. With a superheated locomotive the cooling effect of the cylinder ports, walls, etc., during admission still goes

on, but the process is different. In place of an actual condensation of the steam there is a lowering of the degree of superheat, with a resulting decrease in the specific volume at cut-off. That is, we have a temperature drop from the header to the point of cut-off in the cylinder, and any means of reducing this drop results in a larger specific volume with greater economy.

Referring to Fig. 7, if we let

v_i = volume of steam caught in clearance space at compression, but reduced to an equivalent volume at cut-off pressure
v_c = total volume of steam at cut-off
v_{ST} = specific volume of superheated steam at temperature T at cut-off
N = number of revolutions per minute, and
A = area of card reduced to ft-lb. of work,

then for the indicated horsepower we have

$$H_p = \frac{4NA}{33{,}000}$$

and for the steam consumption per hour,

$$\text{Lb. per hr.} = 4\left[\frac{v_c - v_i}{v_{ST}}\right]N$$

Therefore the steam consumption per horsepower per hour is

$$h = \frac{4\left[\dfrac{v_c - v_i}{v_{ST}}\right]}{\dfrac{4NA}{33{,}000}} = \frac{1}{v_{ST}}\left[\frac{(v_c - v_i)\ 33{,}000}{A}\right]$$

This equation shows four ways of reducing the steam consumption and thereby increasing the thermal efficiency as well as the capacity of the locomotive:

1 By increasing the card area by reducing wiredrawing, lowering the back pressure to a minimum and getting the best combination of events of stroke.

2 By reducing the cut-off or increasing the expansion ratio.

3 By using the proper compression for the maximum card area for a given supply $(v_c - v_i)$.

4 By increasing the specific volume (i.e., vol. per lb.) of the superheated steam by keeping the degree of superheat as high as possible and reducing the drop of temperature from the header to cut-off in the flow of steam from boiler to cylinder through the ports and clearance space.

For a given cylinder feed $\theta = v_c - v_i$, we have a definite ratio of compression for maximum card area.

Referring again to the indicator card, Fig. 7, the area of the card is given by

$$A = p_1(v_c - v_o) + \int_{v_i}^{V} p\,dv - p_b\,(v - v_k) - \int_{v_o}^{v_k} p\,dv$$

where $p = \dfrac{p_1 v_c}{v}$ during the expansion period

$$= \frac{p_1\,(v_c - \theta)}{v} \text{ during the compression period.}$$

Hence

$$v_k = \frac{p_1\,(v_c - \theta)}{p_b}$$

Therefore

$$A = p_1(v_c - v_o) + p_1 v_c \log_e \frac{V}{v_c} - p_b\left[V - \frac{p_1}{p_b}(v_c - \theta)\right]$$
$$- p_1\,(v_c - \theta)\log_e\left(\frac{v_c - \theta}{v_o}\right)\frac{p_1}{p_b}$$

For the maximum card area,

$$\frac{dA}{dv_c} = p_1 + p_1 \log_e\left(\frac{V}{v_c}\right) - p_1 v_c\left(\frac{v_c}{V}\right)\left(\frac{V}{v_c^2}\right) + p_1$$
$$- p_1 \log_e\left(\frac{v_c - \theta}{v_o}\right)\frac{p_1}{p_b} - p_1(v_c - \theta)\left(\frac{v_o}{v_c - \theta}\right)\frac{1}{v_o} = 0$$

$$\therefore \frac{dA}{dv_c} = p_1 \log_e \frac{V}{v_c} - p_1 \log_e\left[\frac{v_c - \theta}{v_o}\right]\frac{p_1}{p_b} = 0$$

Hence

$$v_k = \frac{V}{v_c} - v_o$$

That is, the compression should increase directly as the clearance and inversely as the cut-off; hence with smaller clearance the compression can be made smaller.

With proper compression, we have for the total card area

$$A = p_1(v_c - v_o) + p_1 v_c \log_e \frac{V}{v_c} - p_b V - p_b v_k \int_{v_o}^{v_k} \frac{dv}{v}$$
$$= p_1(v_c - v_o) + p_1 v_c \log_e \frac{V}{v_c} - p_b V - p_b \frac{V}{v_c} v_o \log_e \frac{V}{v_c}$$

and the m.e.p. $= A/V$.

If we assume a 50 per cent cut-off, 11 per cent clearance volume, and a pressure range from 200 lb. per sq. in. to 20 lb. per sq. in. absolute, then, substituting in the preceding equation, p_m = 139 lb. lb. per sq. in. With the same cylinder feed and 7 per cent clearance

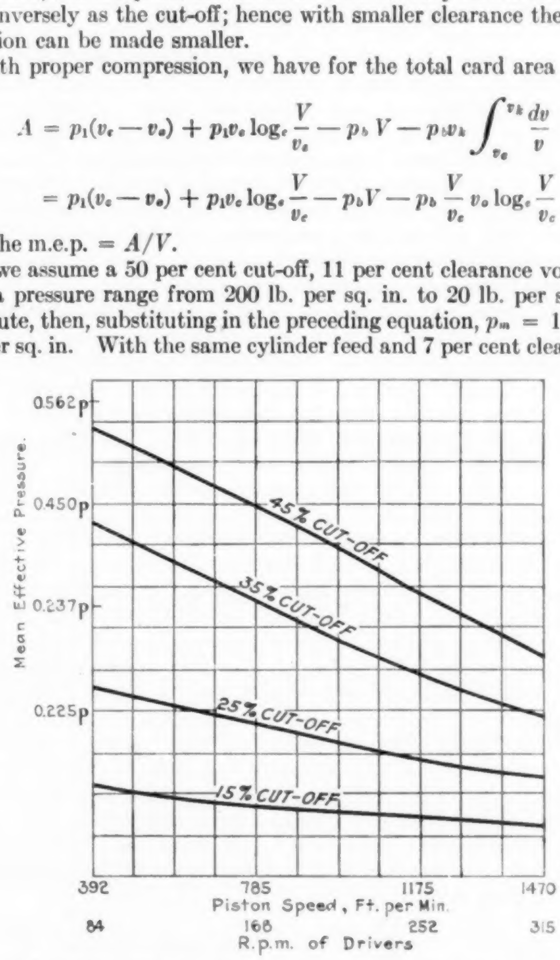


Fig. 8 Wiredrawing Due to Speed and Throttling—Variation of Mean Effective Pressure with Speed at Various Fixed Cut-offs

volume with proper compression, the mean effective pressure is increased to 146.8 lb. per sq. in.

Thus reducing the clearance volume from 11 per cent to 7 per cent for the same steam consumption with correct compression, results in an increase of m.e.p. of 5$^1/_2$ per cent. Due to the impossibility of adjusting for all cut-offs, etc., the actual gain would be smaller.

A more important consideration, however, is that of reducing the amount of surface in the clearance space, which includes the steam passages between valves and cylinders, since the greater part of the initial cooling effect of the steam occurs at this place, due to the relatively slow movement of the piston during the first part of admission.

Wiredrawing and the consequent drop in pressure are due (1) to frictional resistance in passages and (2) to abrupt changes of section. In the flow of steam through short steam passages the latter is the major cause of the drop in pressure. In the passage of steam at early cut-offs we have two large drops in pressure—through the ports and from steam ports into cylinder. Both are due to sudden enlargement of sections. The general theory for the improvement of steam flow is to maintain uniform flow and avoid eddying of the steam by preventing abrupt changes of section.

Due to constructive limitations not much gain can be expected in the further refinement of port passages in the cylinders.

Since the working pressures, superheat, etc. of the average locomotive do not vary greatly, we can measure the cylinder efficiency in terms of h, the steam consumption per hp. Now h varies as a

function of (1) cut-off, (2) speed, and (3) throttle opening. The two latter cause wiredrawing with reduction of card area and mean effective pressure, thus increasing the steam consumption per horsepower developed.

Thus at a given cut-off and with a given steam consumption the mean effective pressure and the consequent horsepower developed decrease with increase of speed. (Fig. 8.)

At full gear and immediately after, the mean effective pressure is determined as a function of the speed, that is, on the wiredrawing effect of the card, and is independent of the evaporative capacity of the boiler. Therefore at low speeds the tractive force is determined entirely by the particular cylinder dimensions and the full-gear cut-off, and decreases with speed due to wiredrawing of the card. With the earlier cut-offs at a given speed a greater steam supply permits the use of a later cut-off with increase of mean effective pressure and tractive force.

The most hopeful chance of improvement on the cylinder end is in the improvement of the thermal conditions of the cylinders. Thus the specific volume of superheated steam increases with the temperature of superheat and it is noted that the steam consumption varies inversely as the specific volume; hence, at 200 lb. per sq. in. pressure,

T_s	v_s	$1/v_s$	Diff.
50	2.49	0.402	...
100	2.68	0.373	0.029
150	2.86	0.350	0.023
200	3.04	0.324	0.021
			0.024

The reduction of steam consumption, assuming the specific volume at 50 deg. superheat at cut-off in the ordinary locomotive, amounts to $(0.024/0.402) \times 100 = 6$ per cent for each saving of 50 deg. fahr. in the temperature drop due to the cooling of the cylinder walls at cut-off. Maintaining a uniform direction of flow, and thereby obtaining a constant temperature gradient of the steam through ports, etc. as in some practical modification of the stationary uniflow engine, would seem to offer a fruitful field in improvement of cylinder efficiency.

Conclusion

In conclusion, it is to be noted that the exact performance of a locomotive is still uncertain and that a considerable amount of experimental work is needed. However, unless such experiments are recorded and guided by some form of preliminary analysis the results lose their generality, and hence their effectiveness for design proportions. In the first part of this paper an attempt has been made to formulate a procedure for properly recording such results for ultimate design proportioning. In our improvement work we must begin by recognizing that the future locomotive will be the result of numerous refinements, the gains being in all cases small. Thus on the boiler end we must first allow as much boiler weight and size as possible, which means diminishing the weight of machinery, etc. to a minimum and giving careful consideration to the thermal balance of the many auxiliaries attached to a modern locomotive, all of which effect a reduction in the allowable boiler weight. This will result in boiler performance at a higher thermal efficiency. Next, the internal boiler proportions consistent with the given weight and space limitations should be such as to give the best efficiency. The efficiency curve should not drop too greatly with the higher rates of firing. On the cylinder end, the details previously considered offer an interesting field for improvement. The gains obtained will not be spectacular, but rather good engineering balance and refinement.

The author is indebted to Mr. C. F. Krauss, of The Baldwin Locomotive Works, for kindly criticism and suggestions in the writing of this paper.

Power Losses in Cotton Textile Mills

By GEORGE WRIGLEY,[1] GREENVILLE, S. C.

This paper deals with power losses within the mill and suggests the difficulties and possibilities of reductions. Much has been done and is being done for the betterment of power generation, but the losses in transmission and utilization are too generally accepted as necessary evils for which there is no remedy or amelioration. It is hoped that thought will be given them, looking to the reduction of any possible waste.

In the cotton textile industry the cost of power averages only about 6 per cent of the total manufacturing cost of the finished product. However, when the size of the industry is considered and the basis changed from percentage to actual power units, this power consumption becomes important. There are in the world today about 162,000,000 spindles, of which 38,000,000 are in the United States. A fair average power estimate is 31 spindles to the indicated kilowatt, or a total of approximately 5,200,000 indicated kilowatts in the world and 1,200,000 indicated kilowatts in the United States. For yearly operation, the world consumption is over 15,000,000,000 kilowatt-hours.

Practically all the power consumed in a textile mill is transferred into heat and only a very small part used in elevating material or stored in the elastic twist of the yarn. This heat performs no useful purpose except, incidentally, to assist in the heating of the mill in cold weather. On the other hand, it increases the sensible warmth in the building in warm weather and makes necessary the supplying of additional artificial humidity so as to provide proper operating conditions.

Power losses are of secondary importance in comparison with sustained high and economical production.

As a primary consideration, any improvement must be economically sound. That is, the fixed charges on the extra capital cost must be less than the cost of the power saved. No power can be considered wasted unless and until an economical method of reducing or eliminating it can be devised.

These power losses within the mill may be divided into two general classes, namely, transmission and utilization.

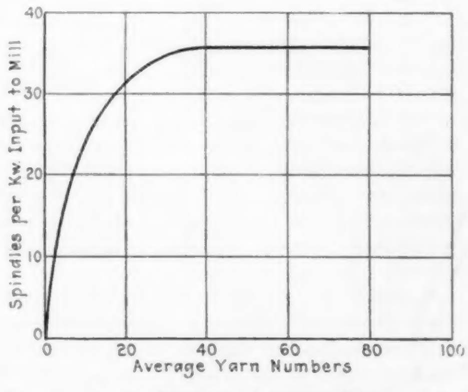


Fig. 1 Chart Showing Average Power Requirements of Cotton-Cloth Mills. These Figures Do Not Include Lighting

Transmission systems may be classified as mechanical, where no electric motors are used, and electrical, where motors in combination with some form of mechanical transmission are employed. Even the individual motor drives embody the use of belts, chains, or gears between the motor and the machine. The losses of transmission are approximately the same whether electric drive or mechanical drive is used.

Electric transmission is now accepted as standard practice, using either the system of moderate-size motors driving small groups of machines, the system of an individual motor for each machine, or a combination of these two systems.

Transmission losses vary with the details of the drive. For instance, a spinning room with four-frame or individual motor drives would show less transmission loss than one equipped with shafting and large motors.

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Presented at the Old Dominion Meeting of the A.S.M.E., Richmond, Va., September 27–October 1, 1926.

In the distribution of power through the cotton-cloth mill about 25 per cent is used in picking, carding, etc., 50 per cent in spinning and spooling, and 25 per cent in weaving and inspection. These figures are generalizations and, of course, vary from mill to mill.

Transmission of power by electrical conductors is now so efficient that any reductions of losses must necessarily be small. However, better operating service, due to better voltage regulation and fewer fuse burn-outs, can be obtained at no increased annual cost by the use of larger conductors than those required by the National Underwriters' Code. Sufficient power is saved even at lower power rates and day operation to warrant some increase in conductor sizes. For day-and-night operation, and especially for higher power rates, still larger sizes are warranted by the power saving.

For silent-chain drives operating between motors and driven machinery, the maintenance records have been very good. Many of these drives on spinning frames have been operating over long periods of years with very small expense. These drives are usually operated on $9^1/_2$-in. centers at chain speeds approximating 1400 ft. per min. They need a continuous though small oil supply rather than sporadic applications of grease.

Chain drives between moderate-size motors and countershafts driving groups of machines through belts have proved quite satisfactory. They embody the good qualities of no slipping between motor and countershaft, low maintenance cost, and the possibility of using short centers.

Ball bearings and roller bearings for lineshaft-hanger bearings have not shown completely satisfactory evidence of sufficient power saving to justify their cost. While the static torque is lowered by their use, the running torque and friction load seems to be the same as for good cylindrical bearing with proper oil supply, as would be expected. Ball bearings for special applications have proved very satisfactory, if properly designed, and are particularly applicable to places where cleanliness is a serious consideration.

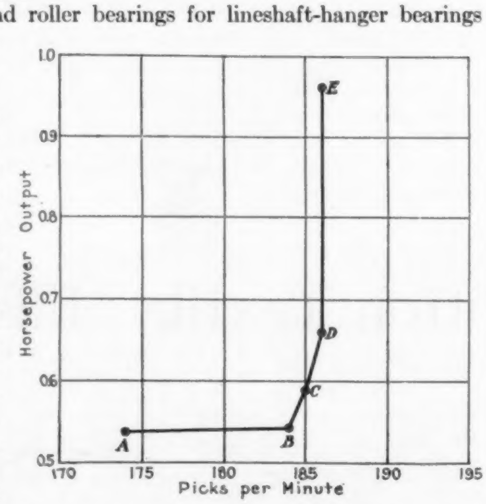

FIG. 2 CHART FROM TESTS SHOWING RELATION BETWEEN CLUTCH PRESSURE, SPEED, AND POWER CONSUMPTION OF LOOM

A—Very light pressure on clutch.
B—Moderate pressure on clutch.
C—Normal pressure on clutch.
D—Slightly excessive pressure on clutch.
E—Heavy pressure on clutch.

Several recent articles dealing with individual motor versus group drive emphasize the possible difference in first cost of the two systems but lose sight of the very important and really crucial question of increased production due to the elimination of slip as made possible with individual drive.

There has been so much said against the use of motors too large for the work that there may be a tendency to go too far in the opposite direction. While it is important to have a motor approximately fit its work, it is a great deal more important that the motor be amply large to safely carry the load. There is little, if any, difference in actual power loss between a motor running at full load and a larger motor running at three-fourths load, so that the greatest argument against over-motorizing is the lower power factor this practice produces.

Present applications of individual motors to textile machinery are not entirely satisfactory. They simply represent the placing of standard motors on standard machines without any great amount of adaptation of the motor or the machine to each other. In some of the other industries this adaptation has been carried to extensive lengths and splendid results achieved.

The individual loom motor drive, while representing a considerable improvement over the old belt drive, is not perfect. The motor and the control device have been well designed and constructed, but the faceplate friction clutch of the loom is inefficient. In the ordinary design the reaction pressure from this faceplate clutch is thrown back on to thrust collars. With the proper amount of friction to hold the clutch without undue slippage, this pressure on the thrust collars is excessive. This results not only in an excessive consumption of power but may overload the motor and burn out the protective thermal cut-outs. In practice, therefore, loom fixers compromise between slippage and power consumption by easing off somewhat on the pressure. This relieves the situation, but each average loom is constantly slipping several picks and it is impossible to obtain full production. Some form of radial-arm clutch is highly desirable to properly correct the trouble.

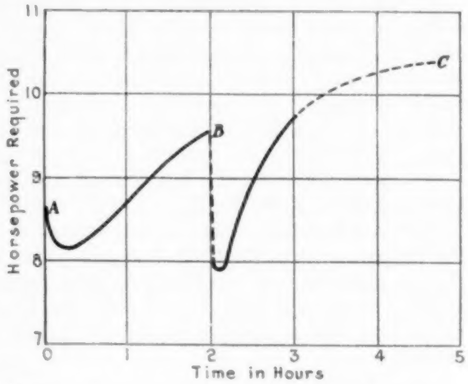

FIG. 3 CHART FROM TEST OF LARGE TWISTER, SHOWING EFFECT OF A TEMPORARY LUBRICATION OF RINGS

A—Starting-bearings cool after $1^1/_2$ hr. shutdown.
B—Machine stopped and rings lubricated.
C—Bobbins full—completion of run.

Textile machinery is wonderfully well made, highly developed, standardized, and admirably performs its function of manufacture. Any improvements in textile machinery will probably be along the lines of small details rather than in radical changes of design. Since the present textile machinery is the product of the inventive genius and highly skilled mechanical refinement of several generations, it is necessary to approach with considerable trepidation the subject of improving it. At the same time, judged from the standpoint of power consumption only, some of the textile machinery is inefficient. The spinning frame and the twister frame are two of the largest users of power, and these machines require almost the same amount of power when running without yarn as when producing yarn. In other words, the principal part of their power load is the friction of the machine parts. One of the largest elements of power consumption in these machines is the high-speed vertical spindle running in its ingeniously designed and well-lubricated bearing. Another considerable one for the larger yarn sizes is the traveler running around its grooved ring at high speed and usually unlubricated.

In spinning and twister frames approximately 50 per cent of the total power consumption is in the spindle bearings or bolsters, 10 per cent in the cylinder, 30 per cent in the travelers and rings, and the remaining 10 per cent in the rolls and traverse motions. In these machines are the greatest possibilities of power saving: first, in an improved method of driving the spindles, and second, in the reduction of traveler friction by continuous lubrication that will not stain the yarn.

In dyehouses, bleacheries, finishing plants, and print works the trend is toward the use of individual motors, frequently of the adjustable-speed type. For driving machines in ranges where automatic speed regulation is essential there are now available suitable alternating-current motors and control equipment for the service. These motors are efficient over a wide range of speeds. In these plants the load factor is relatively low, so that the omission of continuous-running shafting makes possible a reduction in the all-day power losses.

The tendency is to increase rather than decrease the amount of power used for lighting. While wonderful improvements have been made in the efficiency of lamps and in equipment for the control and direction of light and the elimination of glare, the demands for greater intensities have kept ahead of these improvements, and still higher demands are probable in the near future.

Except for possible small savings in conductor and shafting losses, no immediate betterment of transmission appears probable. Large savings, if any, must come in the textile machines, possibly by better and closer adaptation of electric power to the actual work, or by other changes in design.

The Strength of Gear Teeth

By S. Timoshenko[1] and R. V. Baud,[2] East Pittsburgh, Pa.

In this paper the authors discuss stresses in and deflections of gear teeth. By using the photoelastic method the stress concentration at the tooth root has been studied and the factors thereof established for various radii of the fillet. The local stresses at the surface of contact of two teeth in mesh are discussed, using the Herz theory, and it is shown that the most unfavorable conditions are found at some depth beneath the surface of contact. Equations are given for calculating the deflection of teeth, and it is shown that this deflection is usually less than the inaccuracies in commercial gears.

With continued increase in the loading and peripheral speed of gears the problem of the strength of gear teeth becomes more and more important and a deeper study of stress distribution for this case becomes necessary. In the present discussion the problem of stress distribution in the gear teeth is divided into two parts: (1) bending stresses in gear teeth, and (2) local compressive stresses at the surface of contact between two teeth in mesh. In the solution of the first problem the photoelastic method was used, while the second problem was solved analytically. In the latter part the flexibility of gear teeth is discussed and equations are given for calculating the deflection of a tooth, and it will be seen that the calculated values of deflection are in good agreement with experiments.

Bending Stresses in Gear Teeth

Cantilever-Beam Formula. Considering a tooth as a cantilever beam and applying the load at the end of the tooth (Fig. 1), the

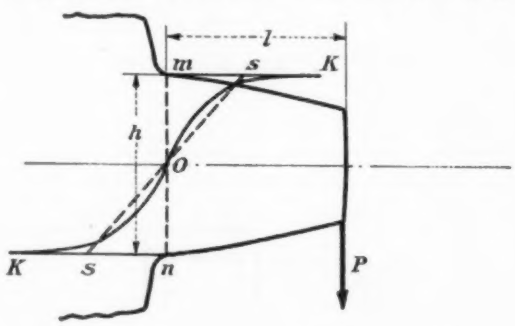

Fig. 1 Tooth Considered as a Cantilever Beam

simple formula for calculating the maximum bending stresses becomes

$$p_{\max} = \frac{6\,Pl}{h^2} \qquad [1]$$

where P = load per inch of face length
l = depth of tooth, and
h = thickness of tooth at the root.

Let t = pitch length; then for an involute gear it can be assumed that approximately

$$l = \frac{2.2\,t}{\pi} \text{ and } h = \frac{t}{2}$$

Substituting in Equation [1] and taking $p_{\max}$ equal to the working stress p_w, the following expression for load P will be obtained:

$$P = 0.06\,tp_w \qquad [2]$$

Speed-Effect Factor

Due to inaccuracies in gear teeth arising from machining conditions and due to vibrations in geared systems the pressures between the teeth in mesh may become much larger than those calculated from the torque moment transmitted. This dynamical effect has the tendency to increase with increase in speed. In order to account for this effect an additional factor diminishing with increase of speed is usually incorporated in the right-hand member of Equation [2]. This factor is purely empirical and several forms of it are used in design. In this country the well-known Lewis formula

$$P = \alpha\,tp_w \frac{1}{1 + \dfrac{v}{600}} \qquad [3]$$

is used, in which

α = factor depending on the shape and number of teeth
v = circumferential speed in feet per minute.

On the basis of the data of leading German firms,[3] the equation for figuring the loading can be put in the following form:

$$P = 0.06\,tp_w\left(1 - \frac{\sqrt{v}}{84}\right) \qquad [4]$$

Equation [3] depends on v and [4] on $\sqrt{v}$. The tendency is to place more importance on the effect of speed in the Lewis formula than is usual in European practice. For comparison some numerical results as obtained for various values of v from Equations [3] and [4] for 20- and 150-tooth involute gears with a 15-deg. angle of action are given in Table 1.

TABLE 1 COMPARISON OF LEWIS AND GERMAN SAFE-LOAD FORMULAS

v = ft. per min. =	600	1200	1800	2400	3000
$0.06\left(1 - \frac{\sqrt{v}}{84}\right)$ =	0.043	0.035	0.030	0.025	0.021
(n = 20) $0.09 \frac{1}{1 + \frac{v}{600}}$ =	0.045	0.030	0.023	0.018	0.015
(n = 150) $0.12 \frac{1}{1 + \frac{v}{600}}$ =	0.060	0.040	0.030	0.024	0.020

From an examination of Table 1 it will be seen that when gears are operating at a low speed (v = 600 ft. per min.) the German and Lewis formulas give about the same values for the safe load P, but at high speed (3000 ft. per min.) the Lewis formula gives about 30 per cent lower load than the German formula. It seems that the tendency to put more importance on the effect of speed in the Lewis formula than is the case with European practice has some justification so far as the dynamic effect of inaccuracies in gear teeth is concerned, and this can be shown as follows: Assume that due to some inaccuracy in tooth form a premature contact between the teeth takes place. Due to this fact the components of the speeds of two teeth on the normal to the surface of contact will be different. The difference Δv of these speeds may give some characteristic of the impact produced by the inaccuracy under consideration. Assume that the speeds equalize[4] during the interval of the time Δt necessary to bring the teeth from the position of premature contact to the true point of contact. Dividing the difference of speeds equally between gear and pinion, the magnitude of acceleration becomes

$$a = \frac{\Delta v}{2\,\Delta t}$$

For any given magnitude of inaccuracy the quantity Δv is proportional to the speed of rotation, and Δt is inversely proportional to this speed. This means that accelerations and additional pressure produced by inaccuracy will be proportional to the square of the circumferential speed v. Due to this fact the safe static pressure P on the tooth should be reduced with the speed as shown in Fig. 2 by the curve mn. The dynamic effect represented in the figure by the shaded area is proportional at any speed to the mo-

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Presented at the Annual Meeting of the American Gear Manufacturers' Association, Detroit, Mich., May 13 to 15, 1926.

[3] See paper by Dolchau in *Maschinenbau*, vol. 4, p. 360 (1925).

[4] See paper by Lasche in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 43 (1899).

ments of inertia of the rotating masses. From this it follows that in order to reduce the dynamic effect the masses rigidly connected with gears must be as small as possible. In the case of heavy masses such as flywheels or rotors, flexible shafts or other types of flexible couplings must be included between these masses and the gears.

Stress Concentration

In Equation [1] a simple bending formula was used, i.e., the linear law of stress distribution over the cross-section *mn* was assumed as shown in Fig. 1 by the line *sos*. In reality considerable stress concentration takes place at the fillets at the root of the tooth, and the actual stress distribution over the cross-section *mn* will be as shown in Fig. 1 by the curve *kok*. The ratio of the maximum stress at the fillet to the stress calculated from the simple beam formula given in Equation [1] will be called the "factor of stress concentration." This factor is of primary importance for the designer and must be taken into consideration when calculating the safe loading on the tooth. In order to obtain factors of stress concentration for various tooth proportions, some experimental work was carried out in which the photoelastic method was employed.

This method, which is well known, consists of making a model of the gear tooth from a suitable material—in this case celluloid—and subjecting it to stress in such a way that any change in the optical behavior of the material can be observed. From this change, which is a color effect, the magnitude of the stress can be computed

The models used in the authors' investigation are shown in Figs. 3, 4, and 5. The first model (Fig. 3) was designed according to widely used proportions. From the base circle to the dedendum

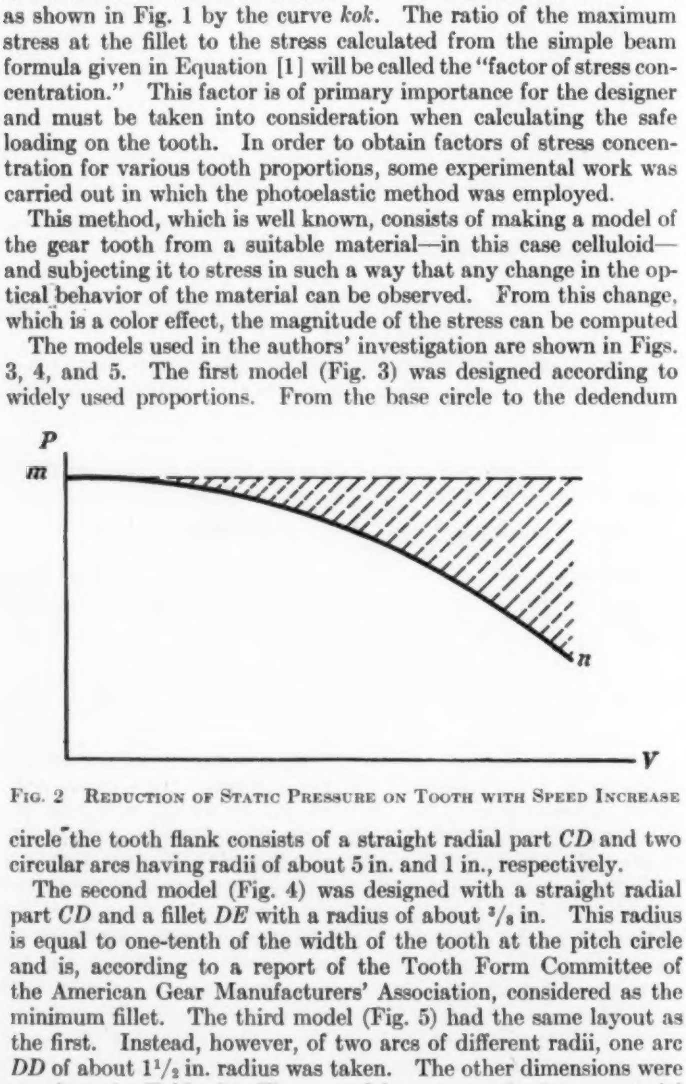

FIG. 2 REDUCTION OF STATIC PRESSURE ON TOOTH WITH SPEED INCREASE

circle the tooth flank consists of a straight radial part *CD* and two circular arcs having radii of about 5 in. and 1 in., respectively.

The second model (Fig. 4) was designed with a straight radial part *CD* and a fillet *DE* with a radius of about 3/8 in. This radius is equal to one-tenth of the width of the tooth at the pitch circle and is, according to a report of the Tooth Form Committee of the American Gear Manufacturers' Association, considered as the minimum fillet. The third model (Fig. 5) had the same layout as the first. Instead, however, of two arcs of different radii, one arc *DD* of about 1 1/2 in. radius was taken. The other dimensions were as given in Table 2. These models were made from material 1/4 in. thick and the stresses along the fillets were obtained by a series of tests. The method of loading is shown in Fig. 6 (see also Fig. 7). Any inclined load P can be replaced by two com-

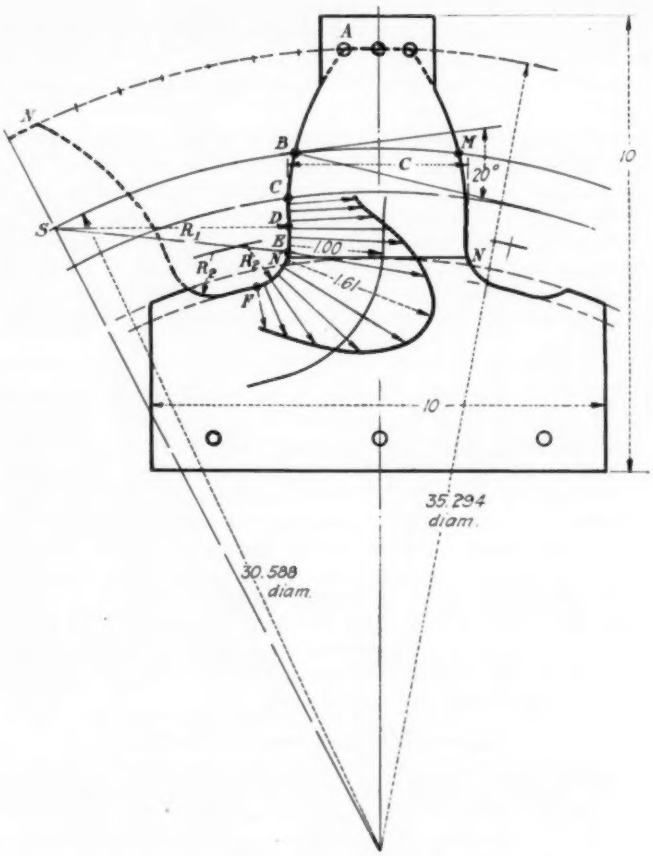

FIG. 3 FIRST GEAR-TOOTH MODEL

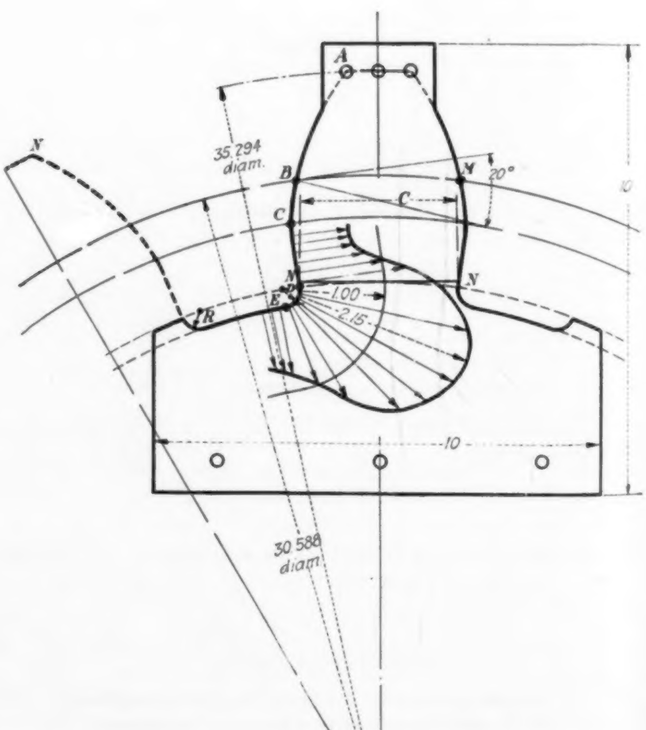

FIG. 4 SECOND GEAR-TOOTH MODEL

TABLE 2 TOOTH-FORM CHARACTERISTICS

Number of teeth N = 13; diametral pitch D.P. = 0.425 in.; involute A-C; angle of pressure α = 20 deg.

	Widely Used Proportions		Inches
Fig. 3	Pitch diameter	13 ÷ D.P.	30.588
	Outside diameter	13 + 2 ÷ D.P.	35.294
	Addendum	1 ÷ D.P.	2.353
	Dedendum	1.157 ÷ D.P.	2.722
	Whole depth	2.157 ÷ D.P.	5.075
	Working depth	2 ÷ D.P.	4.706
	Clearance	0.157 ÷ D.P.	0.369
	Width of tooth at BM	1.5708 ÷ D.P.	3.694
	Radial tooth flank CD	$3.5/N$ ÷ D.P.	0.633
	Radius R_1 = DS (arc DE)		5.188
	Radius R_2 = arc (EF) Arc $AN/7$		1.000
Fig. 4	Fillet radius (equal clearance)	0.157 ÷ D.P.	0.369
	Radial tooth flank CD		1.418
	Other dimensions same as in Fig. 3		
Fig. 5	Dedendum		2.897
	Fillet radius		1.4375
	Whole depth		5.250
	Other dimensions same as in Fig. 3.		

ponent loads P_1 and P_2, and the corresponding stresses can be investigated for each of these loads separately as shown in Fig. 6 (*b*) and (*c*). The complete stresses for the case shown in Fig. 6 (*a*) can then be easily determined by superimposing the stresses set up by the component loads P_1 and P_2. The results obtained for simple bending [Fig. 6 (*c*)] and for the stresses along the fillets are given in Figs. 3, 4, and 5. The tangential stress at any point is shown by a vector in the direction normal to the edge, and the magnitude of the stress is represented to a certain scale by the length of the vector. In order to form a basis for the stress calculation, the unit stress was taken as that stress calculated for the cross-section N-N[5] using the beam formula [1]. This unit stress also is shown in Figs. 3, 4, and 5, so that the factor of stress concentration for all three cases can easily be calculated. As a result of these experiments the factors of stress concentration given in Table 3 were obtained. Furthermore the experiments have shown that the vertical-component load P_1 [Fig. 6 (*b*)] produces practically the same stress concentration as that given in Table 3 for simple bending.

These experiments show that due to this stress concentration the maximum stress is much larger than that calculated on the basis of

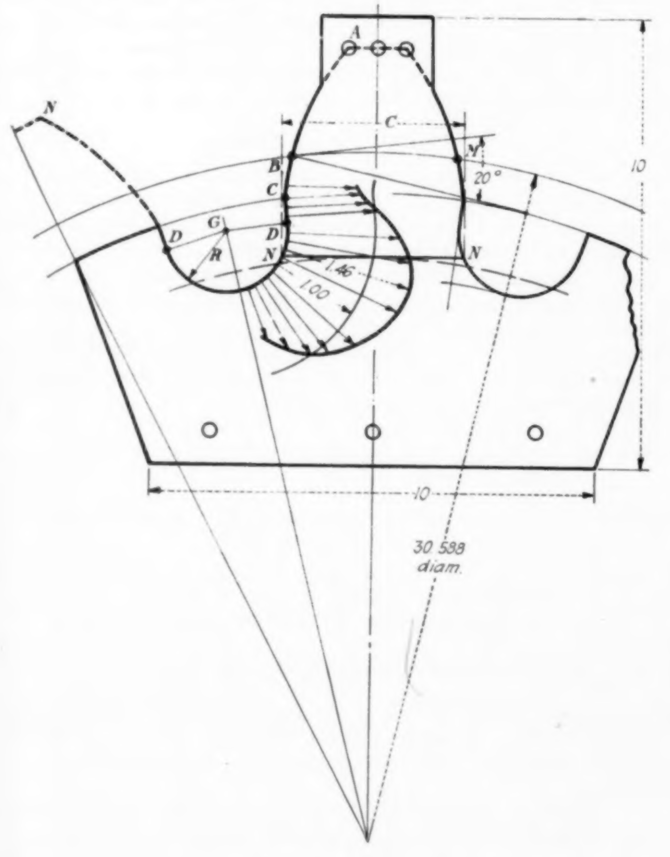

Fig. 5 Third Gear-Tooth Model

the simple beam formula [1], and that by increasing the radius of fillet the strength of gear teeth can be considerably increased. It is

TABLE 3 FACTORS OF STRESS CONCENTRATION

Fig.	Fillet radius R	R/c	Factors of stress concentration, K, bending [Fig. 6(*c*)]
	5/16	0.088	2.37[1]
4	3/8	0.104	2.15
3	1	0.260	1.61
5	1 1/2	0.375	1.46

(1) This test was made with a model having the same tooth form as one of a large locomotive gear.

well known that in the case of a ductile material the weakening effect of stress concentration is usually somewhat diminished by yielding of the material at points of highest stress, but in the case of gears in which drastic quenching has been adopted in order to obtain sufficient hardness the material at the root of the tooth may not have sufficient ductility, and the full weakening effect of the stress concentration as given in Table 3 must be taken into account.

This can be done by using the following equation instead of

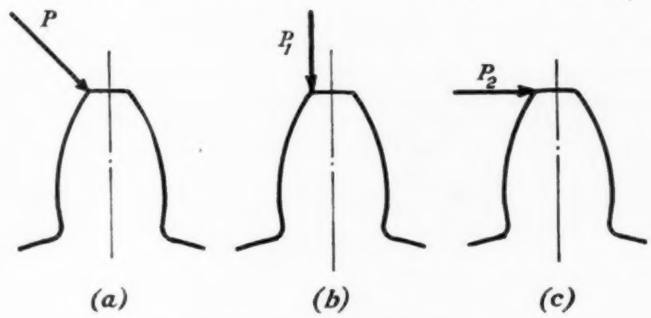

Fig. 6 Methods of Loading Teeth

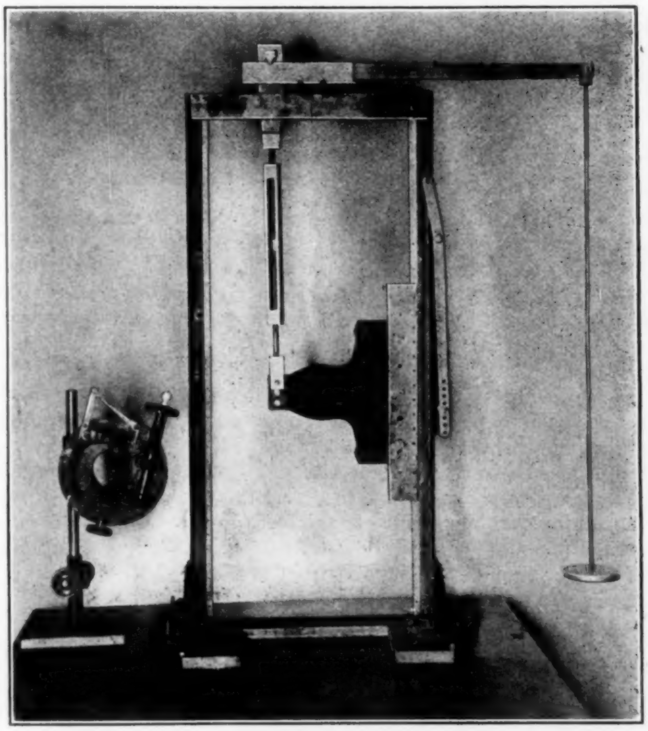

Fig. 7 Apparatus Used in Loading Gear-Tooth Models

[3] for calculating the safe loading:

$$P = \alpha\, \beta\, tp_w \frac{1}{1 + \dfrac{v}{600}} \qquad [3a]$$

Here the factor β will depend only on the fillet proportions at the tooth root. The authors propose to take for this factor the following value:

$$\beta = \frac{1.6}{k} \qquad [3b]$$

where k is the factor of stress concentration and can be calculated from the equation

$$k = 1 + \frac{0.15\, c}{R} \qquad [3c]$$

Then for the usual proportions (see Fig. 3) β is about 1.0. For the case of small radius (Fig. 4) β will be less than unity, and in the case of a large fillet radius (Fig. 5) this factor will be greater than unity and the loading can be therefore increased accordingly.

[5] This is the section perpendicular to the axis of the tooth and tangent to the working-depth circle. The corresponding width is denoted further by c.

For the three cases given in Figs. 3, 4, and 5 we obtain from Equations [3b] and [3c] the following values:

R	R/c	β
3/8	0.104	0.66
1	0.260	1.01
1 1/2	0.375	1.14

In addition to the stresses produced by the load acting on the tooth, stresses due to shrink-fit pressure also may have to be taken into consideration. In order to obtain stresses at the tooth root due to shrink-fit pressure, some experiments with models such as shown in Fig. 8 were made. The variation of tangential stress along the fillet, as obtained from experiments, is shown in Fig. 8. For purposes of comparison the unit stress corresponding to simple tension is also shown in the figure. The factor of stress concentra-

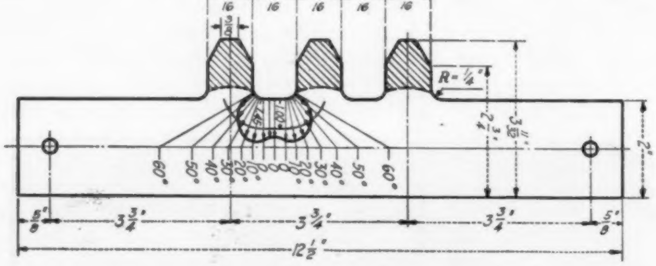

Fig. 8 Tooth Models Experimented with in Obtaining Stresses at Root Due to Shrink-Fit Pressure

tion obtained for this case was equal to 1.45. It was also found that the stresses due to shrink-fit pressure do not appreciably affect the maximum stresses produced by bending of the tooth, so that Equations [3b] and [3c] can always be used in studying the strength of gear teeth.

Local Stresses at the Surface of Contact

In the preceding paragraphs the question of stresses at the tooth root has been discussed. In the application of gears, however, the problem of local stresses at the surface of contact of two teeth in mesh is also of practical importance. This is especially true when the causes of wear are under consideration.

Assuming that the surface of the teeth in contact is perfect and that the pressure is uniformly distributed along the line of contact, the area of contact will be a strip of uniform width b, which dimension can be found from the following equation:[6]

$$b = 3.04\sqrt{\frac{P}{E} \times \frac{r_1 r_2}{r_1 + r_2}} \quad \ldots\ldots\ldots\ldots [5]$$

in which

P = load per inch length of face

E = modulus of elasticity of material, and

r_1, r_2 = radii of curvature of tooth flanks at the points of contact.

Taking, for example, r_1 = 11.2 in., r_2 = 2.35 in., P = 2000 lb. per in., $E = 30 \times 10^6$ lb. per sq. in., we find from Equation [5] that b = 0.0344 in. This width varies with the displacement of the point of contact along the flanks of the teeth and in the case of involute gears it becomes zero at the base circles, where r_1 or r_2 becomes equal to zero.

The distribution of pressures over the area of contact is of great practical importance, because on these highly localized pressures depends the wearing of gear teeth. It can be assumed that the distribution of pressures over the width b of the area of contact follows a parabolic law (Fig. 9). The maximum pressure at the middle of the surface of contact will be found from equation

$$p_{max} = 1.5\frac{P}{b} \quad \ldots\ldots\ldots\ldots [6]$$

For the numerical example considered above,

$$p_{max} = 1.5\frac{2000}{0.0344} = 82{,}000 \text{ lb. per sq. in.}$$

It is assumed in Equation [5] that the two surfaces in contact are convex. If contact takes place between concave and convex surfaces (as in the case of cycloidal gears) the difference between r_1 and r_2 instead of their sum must be taken in Equation [5]. It is easy to see that such a condition yields a larger value for the width b of the surface of contact. Therefore in this case much lower local stresses must be expected. The compressive stresses in a vertical direction (Fig. 9) are accompanied by compressive stresses in the two principal lateral directions. Taking as a basis of our calculations the maximum-shear theory, the difference between the maximum and minimum principal stresses becomes of importance. In Fig. 9 the variation of this difference with the depth is graphically represented by the curve MN. It is seen from this figure that the maximum shearing stress takes place at a certain depth and not on the surface of contact itself. This fact may give some explanation of the phenomenon of "pitting." If we take into consideration the fact that the maximum shearing stress takes place at a certain depth, it becomes conceivable that a fatigue crack starts at some depth, which gradually develops and results finally in pitting.

On the above basis it seems that some limitation for local compressive stress must be established for various materials used in gears, especially if the thickness of the hardened material is small. We know, for instance, that in the case of nitrogen hardening, in which the hardened layer of material has a thickness of approximately one-third of a millimeter, the maximum pressure as obtained from Equation [6] must not exceed 100,000 lb. per sq. in.

Deflection of Teeth

In the analysis of this problem the following three types of deflection will be considered: (1) Deflection due to flattening of high spots; (2) deflection due to depression at the surface of contact; and (3) deflection of the tooth as a cantilever beam.

Deflection due to flattening of high spots depends on the condition of surface finish. The experiments made with ground surfaces show that this type of deflection can be neglected in comparison with the deflection due to depression at the surface of contact.

Deflection due to depression at the surface of contact can be calculated from the following equation:[7]

$$\delta_1 = 2\,\frac{1 - m^2}{E}\,\frac{P}{\pi}\left(\frac{2}{3} + \log\frac{4r_1}{b} + \log\frac{4r_2}{b}\right) \ldots\ldots [7]$$

where δ_1 = deflection due to depression at the surface of contact

m = 0.3 = Poisson's ratio of the material

$E = 30 \times 10^6$ lb. per sq. in. = modulus of elasticity

r_1, r_2 = radii of the cylindrical surfaces of contact

b = width of the strip of contact between two cylindrical surfaces

P = compressive force per inch length of face.

For calculating the width b of the strip of contact between two cylindrical surfaces Equation [5] should be used. For the numerical example considered above we have, from Equation [7], δ_1 = 0.00052 in.

In calculating the deflection of a tooth as that of a cantilever beam, the beam of variable depth will be considered. For instance, for the case shown in Fig. 10 the deflection will be (notations are indicated in the figure).

$$\delta_2 = \frac{12P\,l^3}{E\,h_0^3}\left[\left(\frac{3}{2} - \frac{a}{2l}\right)\left(\frac{a}{l} - 1\right) + \log\frac{l}{a}\right] + \frac{4\,P(l - a)\,(1 + m)}{(h + h_0)\,E} \ldots [8]$$

The first term on the right-hand side of Equation [8] represents the deflection due to bending moment, and the second term the deflection due to shearing force. Applying the equation for the case of a forged-steel gear rim, in which l = 1.70 in., a = 0.66 in., h_0 = 1.30 in., and P = 2000 lb. per in. length of face, we obtain δ_2 = 0.00046 in. It is seen that for the numerical example the complete deflection

[6] This theory is given by Herz; see also the book Applied Elasticity, by S. Timoshenko and J. M. Lessells, p. 24.

[7] See A. Föppl, Technische Mechanik, vol. 5, 4th ed., p. 346. This equation was developed for calculating compression of rollers. It will also be accurate enough in the present case because the depression is due principally to local deformation.

$\delta_1 + \delta_2$ is about 0.001 in., i.e., smaller than the inaccuracies to be expected in commercial gears of this type.

Equation [8] is based on the usual theory of bending and is accurate enough for those cases where the depth of the beam can be considered as small in comparison with the length of the cantilever. In the problem under discussion this is not the case, and the confirmation of the equation by direct test was obtained.[8] In the authors' experiments two pieces of the gear rim mentioned above were used. The general arrangement of the experiment is shown in Fig. 11. Two symmetrically applied compressive forces produced the deflection of the teeth, which deflection

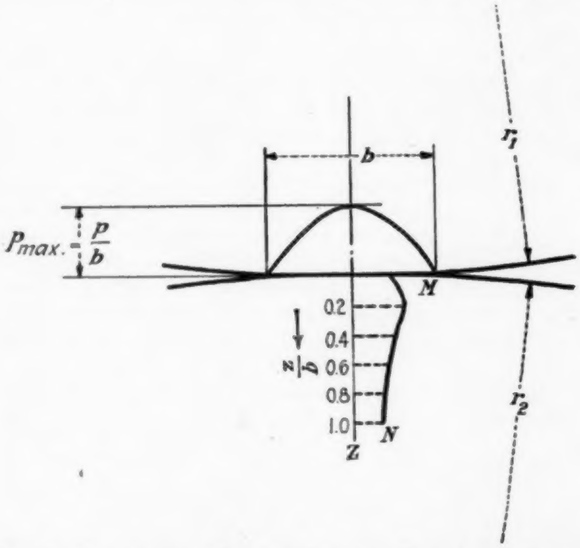

FIG. 9 VARIATION OF MAXIMUM SHEARING STRESS WITH DEPTH

was measured by a Martens extensometer with an accuracy of 0.0001 mm. From the deflection obtained in this way the deflection due to bending and compression of the part of the rim between two loaded teeth was subtracted, which gave a deflection equal to 0.00053 in. for a tooth loaded as a cantilever with P = 2000 lb. per inch length of face. This, as compared with the deflection δ_2 = 0.00046 in. obtained from Equation [8], shows that the actual deflection is about 15 per cent larger than that given by the cantilever formula.

We see that the deflection is small, but in studying the impact

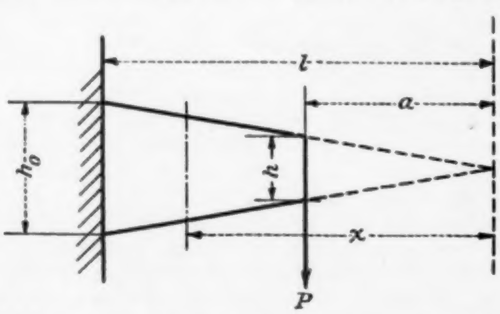

FIG. 10 DEFLECTIONS OF TOOTH CONSIDERED AS A CANTILEVER BEAM

between the teeth, due to various kinds of inaccuracies, this deflection must also be taken into consideration.

CONCLUSIONS

1 It is shown in this paper that due to stress concentration at the root of the tooth the maximum stress is higher than that given by the simple cantilever-beam formula. This maximum stress can be substantially diminished and the strength of teeth increased by an appropriate increase in the radius of the fillet. The values of the factor of stress concentration k for fillet proportions R/c other than those of the tests and the corresponding factor β, which it is suggested should be added to the Lewis formula, can be obtained by using the Equations [3b] and [3c] given in this paper.

2 The stresses at the tooth root due to shrink-fit pressures have been studied by the photoelastic method and it is shown that these stresses do not materially change the maximum stress produced by tooth pressure.

3 The local stresses at the contact area of the two teeth in mesh can be calculated by using the Herz theory. These local stresses must be taken into consideration in studying the wearing of gears. It is shown that the most unfavorable stress condition takes place

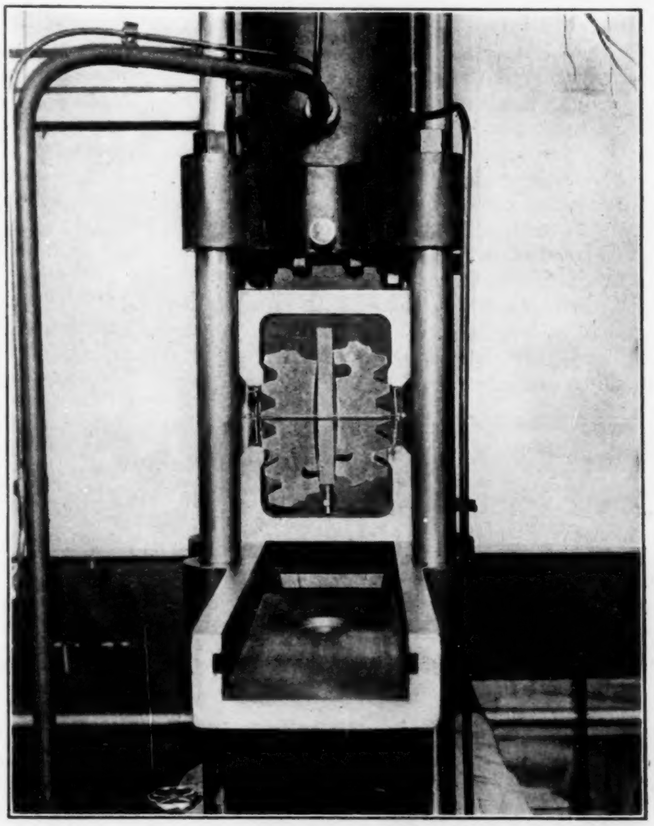

FIG. 11 METHOD OF TESTING DEFLECTION

at a certain depth beneath the surface of contact. This fact may give some explanation of the phenomenon of "pitting."

4 The deflection of teeth can be divided into deflection due to depression at the surface of contact, and deflection of the tooth as a cantilever beam. The first part of the deflection can be calculated from Equation [7]. For the calculation of the second part an equation similar to Equation [8] and depending on the tooth form must be used. Deflections obtained in this manner are very small, but they must be taken into account when impact between the teeth resulting from the various inaccuracies in teeth is under consideration.

[8] In these tests the authors were assisted by Mr. P. L. Irwin.

Results of steaming tests with representative Indiana coals are presented in Bulletin No. 26—Purdue Engineering Experiment Station, by A. A. Potter, A. W. Cole, W. E. Gray and J. P. Walsted. The 212 tests reported were conducted on a great variety of hand-fired and stoker-fired boiler plants, and most of them were secured under ordinary operating conditions.

The tests reveal overall boiler efficiencies as high as 69 per cent with fire-tube boilers and 78 per cent with water-tube boilers. Boiler capacities of 125 or 130 per cent of rating were secured with hand-fired grates, and capacities as high as 275 or 280 per cent with stoker-fired boilers.

Setting design and care in operation seem to be the two major factors which influence ratings and efficiencies. With proper furnace design, a reasonable amount of care on the part of the plant operators will insure satisfactory results with Indiana coal.

Copies of this bulletin may be obtained by addressing the Director of Engineering Experiment Station, Purdue University, Lafayette, Ind.

Apprentice Training

History of the Apprenticeship System—Problems Encountered at the Newport News Shipbuilding and Dry Dock Company's Works—Illustrations of System's Operation—Conclusions Reached

BY CHAS. F. BAILEY,[1] NEWPORT NEWS, VA.

IT IS THE purpose of this paper to give a brief history of the apprentice system in force at the works of the Newport News Shipbuilding and Dry Dock Company; to outline the problems encountered in the various trades in which apprenticeships are offered; to illustrate the operations of the system in the different departments; and to present some helpful conclusions based upon the experience of those who are dealing with this problem.

Apprentice courses have been offered by the company for over thirty years, and it still has in its employ the first apprentice to complete his time. The early apprentice courses followed the then usual trend, with but slight attention given to the individual needs of the boy. Night schools were also started.

With the coming of Homer L. Ferguson to the yard as superintendent of construction about twenty years ago, apprentice training was given a new impetus, and it has been developing and expanding ever since. At the present time, with about 6000 employees, there are about 220 apprentices, in sixteen or seventeen different trades.

FIG. 1 PATTERN SHOP, APPRENTICES, AND PATTERNS MADE BY THEM

GENERAL OUTLINE

Supervision. The employment manager exercises a general advisory control over the apprentice training; the active administration, however, is by a supervisor of apprentices assisted by a corps of teachers and instructors.

Trades Represented. Apprentices are now serving in the following trades: Machinist, joinery, patternmaking, molding, steam engineering, electrical work, painting, anglesmith, hull fitting, sailmaking, mold-loft work, plumbing, coppersmithing, drafting, sheet-iron work, ship-carpenter work, welding, and others. About sixty per cent of the boys have attended high school for a year or more, and approximately fifteen per cent are high-school graduates.

Requirements and Conditions. The courses are of four years' duration, divided into eight terms of six months each. The minimum age for entrance is sixteen years. Apprentices in the drafting rooms must have had at least two years of high-school work, or the equivalent, and must have served four terms in the yard. Candidates must present certificates of good moral character and must stand a physical examination by the company's surgeon upon entering. The pay ranges from about thirty per cent of a journeyman's wage for the first term to about sixty-five per cent for the last term. Apprentices are sometimes allowed to do piece, premium, or contract work, in which case their pay may amount to considerably more.

School Work. For a period of approximately nine months each year, daily sessions are held for study in the classrooms. Each apprentice attends two half-days each week during the regular working hours with pay. Monthly reports of the schoolroom work and the shop work are made, rating each apprentice on his trade ability under the headings, *workmanship*, accuracy, application, aptitude, and skill; *character* is rated under the headings interest, initiative, judgment, conduct, and moral sense; school work and shop work are rated by percentages.

Reports, Completion of Apprenticeship. Monthly reports are required from the instructors, both in shop work and school work. Apprentices who do not meet the required standards are not advanced to the succeeding grades. An artistic certificate is presented to the apprentice on the satisfactory completion of his course, at which time a cash bonus of $100 is also given.

PRACTICAL APPLICATIONS

Premium Work. The policy of promoting contract, premium, or piece work, by which the boys are enabled to materially increase their earnings, is being pursued. Such work tends to bring out the best in the boys, stimulates their interest, sets them to thinking, and raises their efficiency and morale.

School Session. The practice of conducting the school during working hours is found to give the best results. The control is better and the coördination between shop and school work is closer than when the studies are given outside of working hours. However, some of the more ambitious and brighter apprentices take evening classes in addition to their regular shop training and class work.

Promoting Interest. Incentives are provided, such as distinguishing the benches by numbering to indicate excellent performance; posting the marks for public notice; presenting minor prizes in the form of tools or small gold pieces; citation or promotion for special effort or exceptional performance; the granting of scholarships in evening schools or in correspondence courses; and, as the highest reward, a scholarship allowing contingent expenses in some higher institution of learning for a period of one, two, or more years. The incentives are so offered as to create a lively spirit of competition, and it is intended to make them sufficiently numerous so as to encourage the slower, but well-meaning, boys.

Extraneous Activities. Athletics constitutes one of the principal activities outside of the working hours. The spirit of sport is encouraged by the management and particularly by the employment manager and the supervisor, who coöperate and coördinate in all matters concerning the apprentices.

The apprentices have fitted up a very attractive club room which is open for meetings of committees, the council, or for interviews during the day. Each evening the club is open, the boys taking turns in assuming charge.

It is not intended to convey the idea that obstacles and difficulties are not encountered—there are many of them. Some of these have been satisfactorily solved by the boys themselves. As an example, a few weeks ago a group of six of the more influential apprentices desired to take a brief leadership course at Blue Ridge, North Carolina. They were assisted in this by the company, who paid a portion of their expenses. When they left for this training the supervisor propounded several questions of a hypothetical nature bearing on apprentice problems. These were carefully considered and worked out with such reasonable and practical answers that a number of them have already been put into effect with gratifying results.

[1] Engineering Director, Newport News Shipbuilding and Dry Dock Company. Mem. A.S.M.E.

Paper presented at the Old Dominion Meeting of the A.S.M.E., Richmond, Va., September 27–October 1, 1926. Abridged.

Thrift is encouraged and practiced through an apprentice banking organization.

Method of Discipline and Resulting Influences

Self-Government. The government of the apprentice body is administered under a constitution adopted by the apprentice association which provides for self-government. The supreme authority rests in an Honor Council, composed of ten representatives from the various departments. There are also honorary members of the Council. The members are elected by and from the apprentices, and serve during the remainder of their apprenticeship or during good behavior. Election is by secret ballot. The Council makes and executes all the rules and regulations governing the apprentices and acts as representative of the body. It settles grievances or complaints, provides for election and interprets the constitution and by-laws. The employment manager and supervisor are ex-officio members, in an advisory capacity, but without the right to vote. This form of government has proved most satisfactory, and is considered one of the outstanding influences for good.

Good-Will. A large proportion of the mechanics employed in the yard are apprentice graduates and constitute the most capable, loyal, and efficient part of the force. This applies not only to the workmen but also to the sub-foremen and foremen.

Habits. We can hardly overrate the importance to the youth of the formation of right habits during his apprenticeship. The governing body and the Honor Council exert a powerful control over their associates in this respect. With apprentice groups who are keen and alive to their advantages; who are deeply interested in their trades; who have agreeable associates with like ambitions and high ideals of character and deportment; who have inspiring traditions of the past, and who realize that they must uphold and contribute to these traditions, it may reasonably be assumed that a good proportion of such men will be in sympathy with and help to promote all endeavors to increase efficiency and production.

Such ideals may, to a large extent, be implanted in the minds of a goodly number of the boys by the supervisor, the instructors in the school, and those who teach them in the shops. This influence is constantly exerted by the Honor Council or governing body. In the matter of discipline they are usually more severe in their requirements than the instructors.

General Comments

Good-Fellowship. Annually, after the foot-ball season has closed the company gives a banquet to the entire body of apprentices. These functions are held in the high-school building. The city school officials, representatives of the press, a few prominent guests, and the officials, superintendents and foremen of the company are invited. The occasion is enlivened with music by the apprentice band, snappy speeches, to which the boys also contribute, and apprentice yells occasionally sandwiched in. The enthusiasm and spirit which prevail on these occasions continue long thereafter.

Owner's Interest. The principal owner of the yard, Henry E. Huntington, is particularly interested in the development of the apprentice idea as it is being worked out at Newport News. On his occasional visits he always desires to inspect the school and to learn about the numerous activities in which the apprentices are engaged; while away he sometimes exchanges felicitations with them through the Honor Council. His attitude and the advanced and liberal policy of the president, Homer L. Ferguson, greatly encourage both the apprentice body and the entire staff who administer the work.

Spreading Influence. While a goodly number of the graduates remain with the company, many seek a future in other lines of manufacturing scattered all over the country. A few are successful in municipal work—the city manager of Newport News is an apprentice graduate of 1921. Others have established themselves in profitable business in different localities.

Conspicuous among the careers chosen, however, is service in the American Merchant Marine. In this the company always encourages the young graduate, if he desires sea service, realizing as it does how vital such trained men are for the operation of the Merchant Marine, on which the prosperity and safety of the nation depend.

Conclusions

Experience demonstrates the value and importance to the employer and the employee, and to the country, of wisely conducted apprentice training:

a It provides a nucleus of skilled mechanics in the various trades essential to any large engineering concern, particularly in work which is not adapted to mass production.

b It creates and maintains a spirit of understanding and practical loyalty between mechanics, foremen, superintendents, and management.

c It greatly assists in recruiting and stabilizing the ranks of quartermen, sub-foremen, foremen, and superintendents. These are all men who come in intimate contact with the inspectors and representatives of the clients of the company and hence largely promote the good name of the concern.

d It furnishes the cream of the personnel to man our Merchant Marine and Navy.

e It helps to establish, especially in towns of medium size, civic pride, spirit, and interest in schools, churches, public improvements, and clean government.

Fig. 2 Condenser Shell Made by Apprentices for Panama-Pacific Steamship

f It offers opportunities and possibilities to young men, who consistently strive by study and application to understand and practice the cardinal principles underlying the work they are doing and the job above them.

g It fosters the education of a personnel alive to the importance of efficiency, low production costs, satisfactory quality, and to the balance between these elements, with the reasons therefor.

h It identifies the young men of character, unusual worth, ability, and resourcefulness, so that the company may advance such men and thus build up its morale.

i It constitutes a vital service to the community and to the country to thus train up skilled mechanics with correct ideals as to their high worth and honorable place in society.

j Finally, as Spencer Miller, Sr.,[2] has said, the cornerstone upon which apprentice training rests is "respect for skilled craftsmanship. This means, in essence, love of one's work, And when man works at the thing he loves, it is well for the man and well for the work." And next in importance is "the development of the character of the apprentice by giving him definite social responsibilities to discharge."

[2] Transactions of the Society of Naval Architects and Marine Engineers, vol. 31, p. 15, 1923.

Fluid Flow in Pipes of Annular Cross-Section

By D. H. Atherton,[1] Berkeley, Cal.

The object of the investigations reported in this paper was to determine the actual values of the friction coefficients for the flow of air, oil, and water through pipes of annular cross-section. The apparatus and method of testing are described and the data and results of the tests are given in graphic and tabular form. It appears that the coefficient of friction corresponding to any given turbulence factor for both turbulent and viscous flow has a value for pipes of annular cross-section slightly higher than for pipes of circular cross-section when determined by the equivalent-diameter formula.

In problems of fluid flow, which involve the determination of the pressure drop or loss of head due to friction, the formula most commonly used for conditions of turbulent flow in pipes of circular section is the one variously attributed to Chézy, Fanning, or Darcy,[2] namely,

$$\Delta p = \frac{4fwlV^2}{2gd} \quad \text{[1]}$$

and for sections other than circular,

$$\Delta p = \frac{fwlV^2}{2gm} \quad \text{[2]}$$

in which V = velocity, ft. per sec.
w = density, lb. per cu. ft.
u = viscosity, poundals-sec. per sq. ft.
l = length, ft.
d = diameter, ft.; ($4/d = 1/m$ for circular sections)
f = coefficient of friction
m = mean hydraulic radius, ft.
Δp = drop in pressure, lb. per sq. ft.

Values of the coefficient of friction f for flow in smooth pipes of circular section have been shown by the principle of dimensional homogeneity to be a function of the so-called turbulence factor or modulus, dwV/u. Data confirming this have been obtained from extensive experiments covering a wide range of values for all of the variables concerned and show it to be true for all fluids. This function is modified by the roughness factor of the pipe, but at present there is no method by which it may be evaluated; the values which may be used with assurance are those for pipes which have a smoothness or roughness factor equivalent to that of commercial brass tubing.

As far as known there are no experimental data available as to the value of the coefficient of friction f for use in the Chézy equation when it is applied to sections other than circular. It has been customary to determine from the hydraulic radius of the section in question the diameter of a circular section having the same hydraulic radius, and then substitute this equivalent diameter in dwV/u to obtain the corresponding turbulence factor. This having been obtained, the value of f for the same turbulence in circular sections is then used in the Chézy formula.

The object of the research reported in this paper is to determine the actual values of f for annular sections, there being need of such data in problems of fluid flow through such sections, as in heat-exchange apparatus of the double-tube type.

Design and Construction of Apparatus

To avoid the influence of the roughness factor, seamless brass tubes were used, placed one inside another and thus forming an annular cross-section through which the fluid could flow.

The Manometer. A Chattock tilting manometer, shown in Fig. 1, was constructed following closely the description and data in *Engineering* (London) of September 12, 1913. The glass parts shown in Fig. 2, one for air and another for water, were constructed by an expert glassblower. The instrument could be read, if desired, to 0.00006417 in. of water.

The Test Pipe. To insure a pipe of exact and uniform annular cross-section, it was necessary to devise a method by which one pipe would be supported centrally within another but with minimum disturbance of streamline flow. The supports could not be placed too far apart, and yet had to be placed as far as possible from the

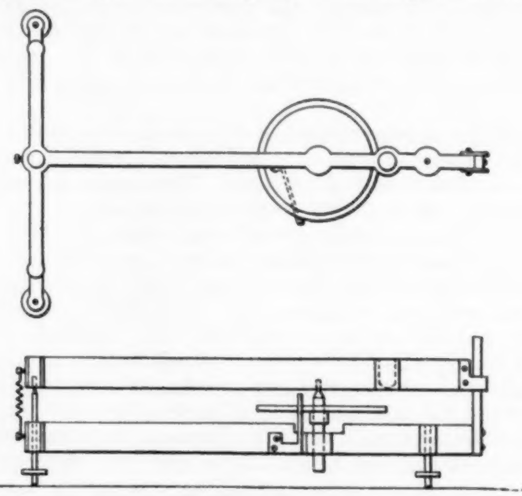

Fig. 1 Chattock Tilting-Manometer Assembly

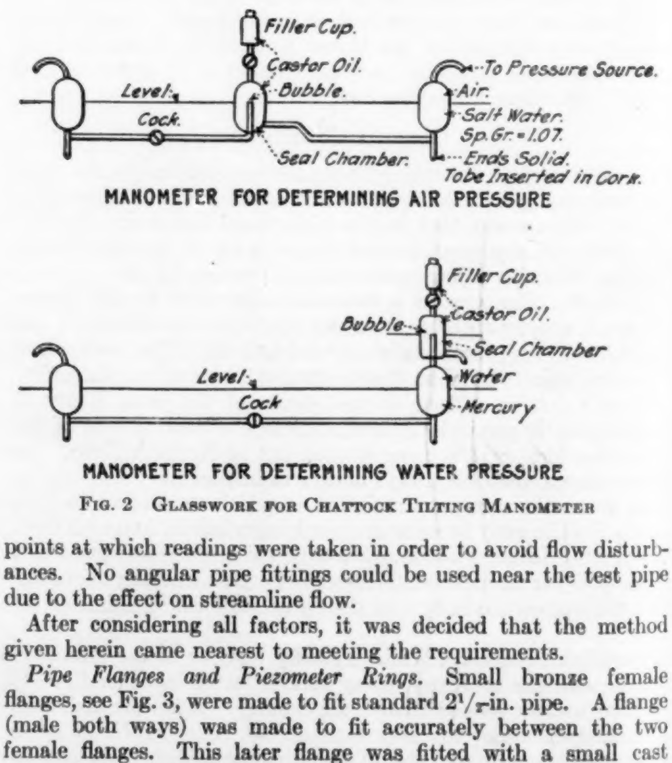

Fig. 2 Glasswork for Chattock Tilting Manometer

points at which readings were taken in order to avoid flow disturbances. No angular pipe fittings could be used near the test pipe due to the effect on streamline flow.

After considering all factors, it was decided that the method given herein came nearest to meeting the requirements.

Pipe Flanges and Piezometer Rings. Small bronze female flanges, see Fig. 3, were made to fit standard $2^1/_2$-in. pipe. A flange (male both ways) was made to fit accurately between the two female flanges. This later flange was fitted with a small cast acorn-shaped center held in place by three cast arms. The cross-section of the arms was that of a flat ellipse, sharp at the edges. Two flanges each of (1) and (2) were required for screwing on to the test pipe and connecting pipes. One flange each of (3) and (4) was required for suspending the inner pipe. The cast a corn-shaped center (4) of the flanges for supporting the inner pipe was drilled and tapped for an adjusting screw.

[1] Assistant Professor of Mechanical Engineering, University of California. Assoc-Mem. A.S.M.E.

[2] Equation [1] is often given by various authorities as

$$\Delta p = \frac{fwlV^2}{2gd}$$

in which the value of f is four times that given above.

Presented at the Spring Meeting, San Francisco, Cal., June 28 to July 1, 1926 of The American Society of Mechanical Engineers. Abridged.

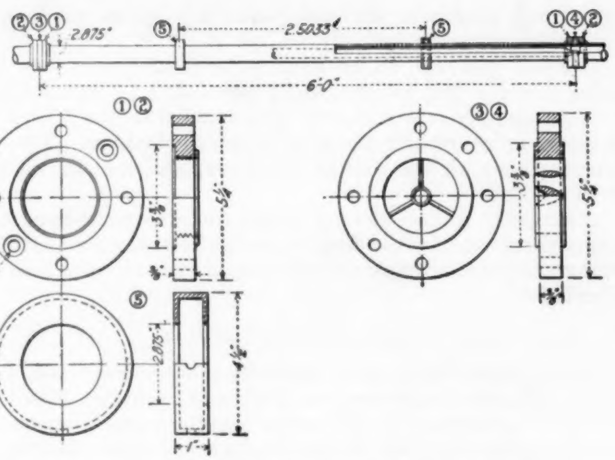

FIG. 3 FLANGES, PIEZOMETER RINGS, AND TEST-PIPE ASSEMBLY

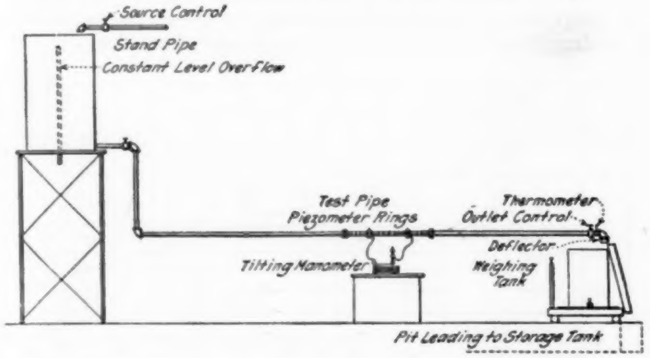

FIG. 4 PIPING DIAGRAM FOR THE FLOW-OF-WATER INVESTIGATION

The inner pipe ends were plugged with brass and both pipe and plugs were then turned and carefully sized. The ends were turned to a 60-deg. acorn-shaped point in order that they might fit into the supporting flanges. This also insured perfect centering of one pipe within the other. All test pipes were of seamless drawn brass tubing. All flanges were carefully finished and rounded.

Cast piezometer rings (5) were soldered to the outer pipe at sufficient distance from the supporting flanges to give at least fifteen diameters distance from the very slight obstruction introduced by the supporting flanges. The supporting flange containing the adjusting screw was placed at the exit end of the test pipe.

In order to make sure that all the holes through the outer pipe into the piezometer ring would be in the same plane, they were drilled with the pipe in a lathe and the drill fastened to the tool rest. By means of machine screws the flanges (3) and (4) supporting the inner pipe could be independently connected to the flanges (1) screwed on the outer pipe. The other two flanges (2) of the two sets were screwed to lengths (at least 20 ft. each way) of standard $2^1/_2$-in. pipe.

The object of this arrangement was to facilitate the changing of the inner pipes for various test runs. Any one of the inner pipes could be inserted and adjusted to position, after which the two could be placed in the line. The bolts which passed through all three flanges of a set could then be inserted and tightened.

In order to facilitate tabulation of data the various pipes were designated by numbers as follows:

Pipe No. 1, the containing pipe on which were mounted the flanges and piezometer rings, inside diameter = 2.3125 in.

Pipe No. 2, the largest inside pipe, outside diameter = 1.85 in.

Pipe No. 3, the intermediate-sized inside pipe, outside diameter = 1.049 in.

Pipe No. 4, the smallest inside pipe, outside diameter = 0.840 in.

EXPERIMENTS WITH FLOW OF WATER

In the experiments with water as the fluid, a standpipe of considerable volume was used, as shown in Fig. 4, provided with an overflow pipe and supply valve so that a constant head could be maintained. The supply valve was controlled by one of the observers. A 3-in. pipe with control valve was led out of the

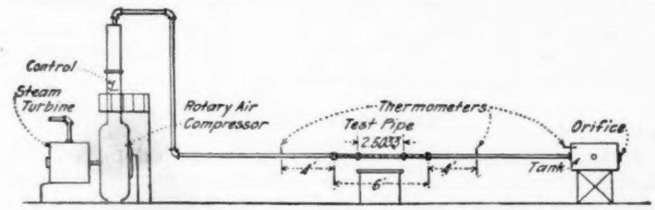

FIG. 5 PIPING DIAGRAM FOR THE FLOW-OF-AIR INVESTIGATION

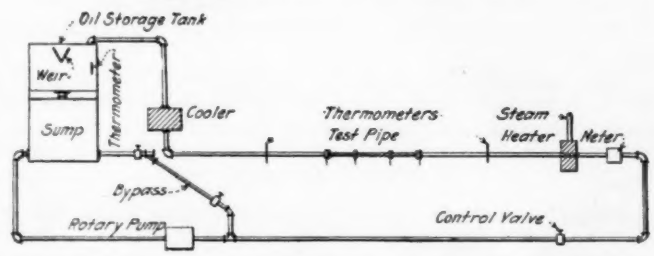

FIG. 6 PIPING DIAGRAM FOR THE FLOW-OF-OIL INVESTIGATION

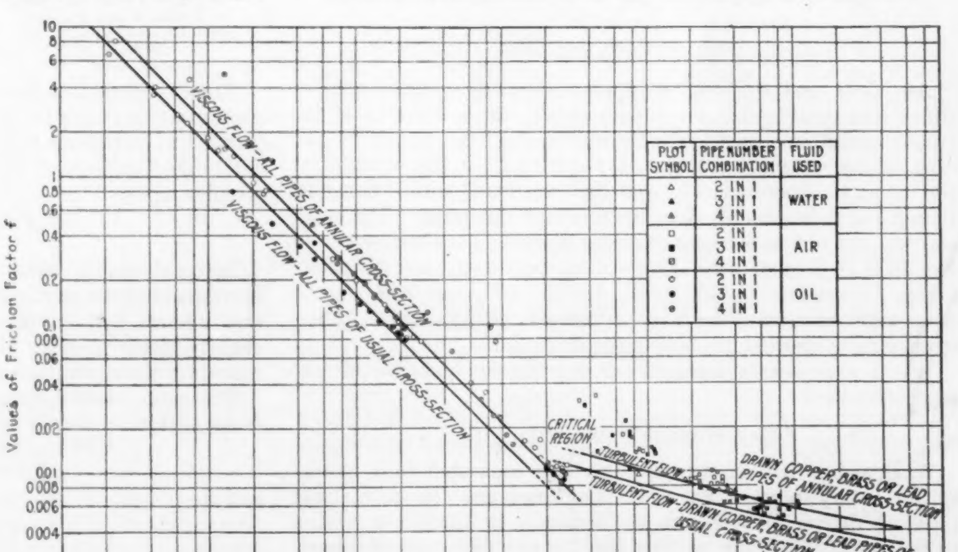

FIG. 7 RESULTS OF INVESTIGATIONS OF RELATION BETWEEN FRICTION AND TURBULENCE FACTORS OF FLUIDS IN PIPES OF ANNULAR CROSS-SECTION AS COMPARED WITH SUCH FLOW IN PIPES OF USUAL CROSS-SECTION

NOTE.—The calculations necessary for solving the test results of this investigation are based on Equation [2] as developed by Chézy. This is the equation for turbulent flow inside sections other than circular. For use herewith the formula becomes, with proper substitutions,

$$f = \frac{2gm\Delta p}{wlV^2} \text{ and } TF = \frac{4mVw}{\mu \times 0.0672}$$

In these formulas

TF = turbulence factor

u = viscosity poundals = μ in poises $\times$ 0.0672

bottom of the standpipe and then down to within 5 ft. of the floor. From that point a straight line of $2^1/_2$-in. pipe 30 ft. in length led to the test pipe. From the test pipe 20 ft. more of $2^1/_2$-in. pipe led to the outlet. At a point 18 in. from the outlet a control valve was placed, and slightly farther toward the outlet a thermometer was inserted directly in the water. A deflector was arranged on the outlet so that the water could be directed either into the weighing tank or into the waste pit.

The Water-Measuring Scale. A standard weighing tank was used consisting of an ordinary portable platform scale on which was placed a cylindrical metal tank of 20-cu. ft. capacity. The rate of flow was controlled by the valve at the outlet end of the pipe line, so that no obstruction to flow was introduced until after the fluid had passed through the test pipe. This arrangement was used in all of the various tests with water, air, and oil.

A considerable number of test runs were made, the last being that of full flow with the control valve wide open, after which this valve was closed and static conditions were rechecked against those obtaining at the beginning. All combinations of pipes together with various rates of flow were used, thereby obtaining data on various sizes of annular cross-section.

Experiments Using Air

In the experiments with air (see Fig. 5), the test pipe already described was connected to a turbo-compressor. Practically steady flow was secured by this means. In this case thermometer wells were introduced into the pipe line 4 ft. from the test pipe on either end. Varying rates of flow were secured by a damper control in the discharge line of the turbo-compressor and also by changing the orifices.

In measuring the flow of air, it was decided that the method given by R. J. Durley[3] exactly fitted the conditions. By this method the pounds per second discharged are

$$0.6299 \times Cd^2\sqrt{i/T}$$

in which C = coefficient of discharge for various heads and diameters
d = diameter of orifice, inches
i = pressure drop between the air inside and outside of the tank, lb. per sq. ft.
T = absolute temperature, deg. fahr.

Air Tank and Orifices. A drum, the cross-sectional area of which was considerably more than twenty times the area of the largest orifice, was used. The drum was also long enough to take care of any velocity of approach resulting from the entrance of the air at the opposite end. One end was fitted with a flange so that it could be connected to the test-pipe discharge. The other end was cut out to receive the orifice plates. They were made of No. 15 B. & S. gage iron. Five orifices were used, their diameters being, respectively, 2.515, 2.006, 1.522, 1.002, and 0.500 in. A manometer connection was made on one side of the drum. A thermometer was inserted in a hole in the drum end.

In the experiments using air all possible combinations of test pipes were used.

Experiments Using Fuel Oil

When using fuel oil the pipe line was connected to a motor-driven rotary pump. For regulating purposes the pump was piped to deliver oil either to the test pipe or through a bypass to the sump. Previous to reaching the test pipe the oil passed through a heater in which its temperature could be regulated within reasonable limits, thereby controlling the viscosity.

After leaving the test pipe the oil passed through a cooler, from which point it returned to the sump. The weir shown in Fig. 6 performs no function other than that of allowing the fluid to return quietly to the sump. The quantity of flow was measured by a calibrated Worthington piston-type meter.

The temperature of the oil entering and leaving the test pipe was measured by means of thermometers placed in the wells located 4 ft. each way from the test pipe. Extreme care and watchfulness were necessary in order to prevent any change of temperature during a run, and the heater was equipped with a bypass which was an invaluable aid to the end.

Starting with the oil at room temperature, runs were made using pipe No. 2 in the containing pipe No. 1. The temperature was successively raised 20 deg. fahr. throughout the desired temperature range, making use of all pipe combinations. The upper temperature limit was that at which evaporation of the oil began to be evident.

A sample of fuel oil, as used in each run, was secured and its viscosity determined by use of the Saybolt viscosimeter, while the specific gravity of the sample was determined by the Westphal balance. (See Fig. 8.)

Discussion of Results

Referring to Fig. 7, upon which have been plotted the results of the tests with air, water, and oil given in Tables 1 to 7, inclusive, of the complete paper, it will be seen that the points fall upon a line closely approaching that for similar conditions in circular pipes.[4]

The results obtained for the flow of air under various pressures, with corresponding changes in density, and for the flow of oil at different temperatures, with corresponding changes in viscosity, plot in consistently with the values obtained for the flow of water.

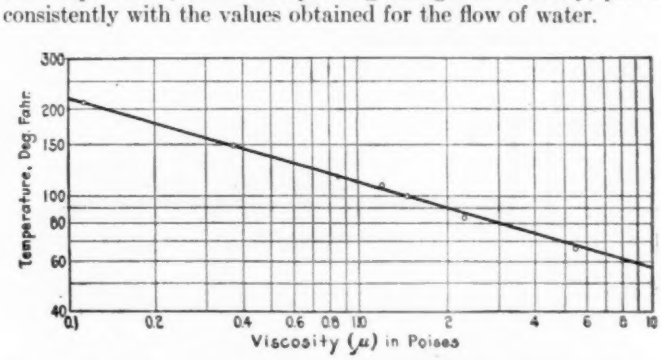

FIG. 8 VISCOSITY-TEMPERATURE CHART OF FUEL OIL, SAYBOLT VISCOSIMETER

$$\mu = w\left(0.0022t - \frac{1.80}{t}\right)$$
$= 1.453$ at 100 deg. fahr.
$= 0.1133$ at 210 deg. fahr.
$= 5.4718$ at 66 deg. fahr.
$(0.0672\mu = \nu)$

$\mu = 2.28$ at 84 deg. fahr.
$= 1.19$ at 108 deg. fahr.
$= 1.45$ at 101 deg. fahr.
$= 0.373$ at 148 deg. fahr.

The curves plotted through the experimental points so obtained are throughout their length, both in streamline and turbulent flow, parallel to and above those plotted for the values which have been established in the past for flow under similar conditions in smooth circular pipes.

Conclusion

In conclusion, it would appear that the coefficient of friction corresponding to any given turbulence factor for both turbulent and viscous flow has a value for pipes of annular cross-section slightly higher than for pipes of circular cross-section, when determined by the equivalent-diameter formula.

The ratio between these two values, for any given turbulence factor, determined from the graph, Fig. 7, is

$$1:1.26 \text{ for turbulent flow}$$

and

$$1:1.36 \text{ for viscous flow.}$$

If then f is the friction factor of fluids flowing in pipes without inside cores and if f' and f'' are respectively the friction factors of turbulent and viscous flow in pipes containing inside cores, then

$$f' = 1.26f \text{ for turbulent flow}$$

and

$$f'' = 1.36f \text{ for viscous flow}$$

for use in formulas dealing with flow of fluids through pipes of annular cross-section.

[3] Trans. A.S.M.E., vol. 27 (1906), p. 193.

[4] Hydraulics of Pipe Lines, by W. F. Durand, p. 261; *Journal of Industrial and Engineering Chemistry*, vol. 14, pp. 105 to 119, Flow of Fluids Through Commercial Pipe Lines, by R. E. Wilson, W. W. McAdams, and M. Seltzer.

Refractories Service Conditions in Furnaces Burning Pittsburgh Coal on Chain Grates

Progress Report of A.S.M.E. Special Research Committee on Boiler-Furnace Refractories

By RALPH A. SHERMAN[1] and W. E. RICE,[2] PITTSBURGH, PA.

THIS report presents data obtained as a part of the investigation of the proper application of boiler-furnace refractories which is being conducted by the Bureau of Mines in coöperation with the special research committee of The American Society of Mechanical Engineers on boiler-furnace refractories.

The data pertain to the furnace conditions which affect the life of refractories in furnaces burning coal from the Pittsburgh No. 8 seam on chain-grate stokers. The investigation was conducted at the 70th Street station of the Cleveland Electric Illuminating Company, Cleveland, Ohio. Some discussion of the data obtained and their meaning is included in the present report, but a full interpretation has not been attempted.

The stoker-fired boilers at this station, all of which are of the Stirling type, include 18 with natural-draft, 41 with induced-draft, and 18 with forced-draft stokers. The principal cause of refractories failure in those furnaces with natural and induced draft is spalling, both on the arches and on the side walls. Slag erosion is a cause of failure to some extent on the side walls, but is considered minor in comparison with the spalling. Considerable erosion by slag occurs on the back wall of those furnaces in which the stoker is set under the mud drum of the boiler.

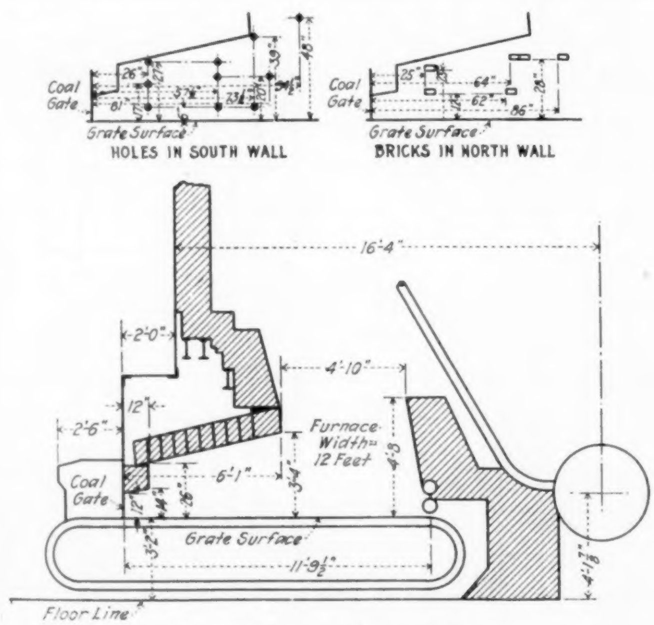

Fig. 1 Furnace Measurements

The principal cause of side-wall failure in the forced-draft-stoker furnaces is slag erosion, while the arches spall as they do in the induced-draft furnaces, with little or no slag erosion apparent.

The present investigation was confined principally to a forced-draft stoker-fired furnace, with certain observations on an induced-draft furnace.

Forced-Draft Stokers

The forced-draft-stoker furnace studied, known in the station as No. 18, was under a boiler having 6865 sq. ft. of heating surface, fired with a stoker having an effective grate area of 138 sq. ft. It was equipped with a flat suspended ignition and main arch. The volume of the furnace was 1447 cu. ft.

The evaporation of this boiler at 100 per cent of rating was 19,650 lb. of steam per hour at 225 lb. pressure, 150 deg. fahr. superheat, and 150 deg. fahr. feedwater temperature.

Sections of the furnace giving principal dimensions, location of the holes for measuring temperatures and sampling gases, and location of the bricks in which temperatures were measured in the side wall and arch, are shown in Figs. 1, 2, 3, and 4, respectively.

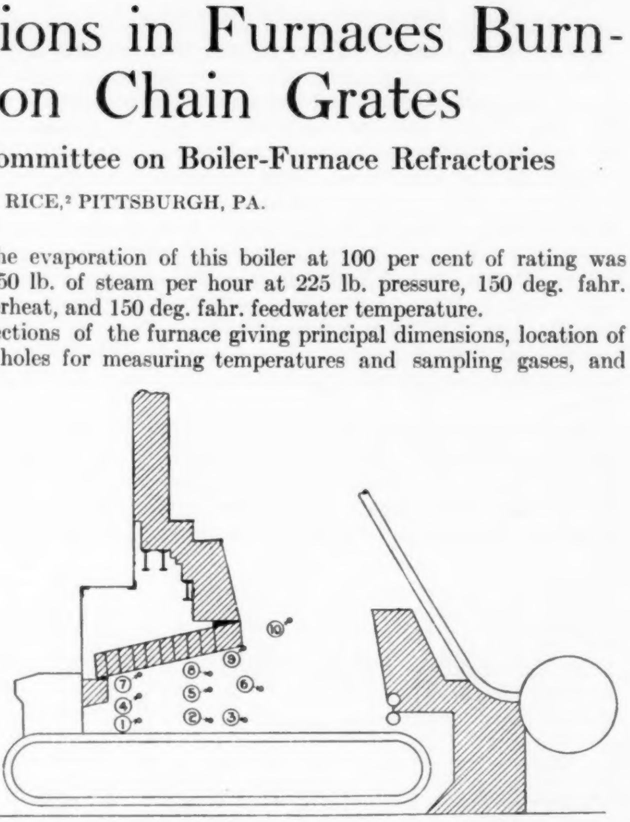

Fig. 2 Section of Furnace Showing Positions of Holes in South Wall Through Which Gas Samples Were Drawn and Gas Velocities and Temperatures Measured

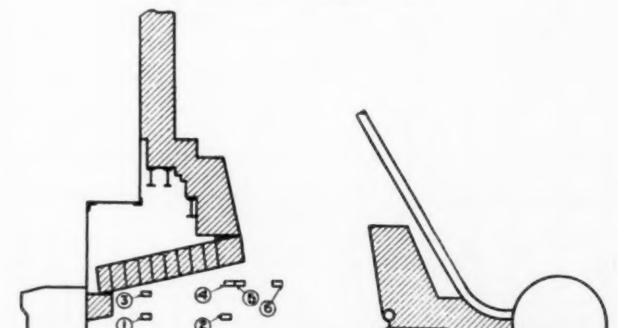

Fig. 3 Section of Furnace Showing Bricks in Which Temperatures Were Measured (North Wall)

Coal

The two principal classifications of coal burned at the station were known as Dillon, and Youghiogheny and Ohio, received both in run-of-mine and slack sizes. These coals come from mines in Belmont and Jefferson counties, Ohio. Crushed Dillon run-of-mine coal was burned in this furnace during the period of observations. This is a coking coal and is quite sensitive in its burning on chain grates to the moisture content and fineness of crushing.

A representative proximate analysis of this coal follows:

	Per cent
Moisture	5.5
Volatile matter	37.4
Fixed carbon	46.0
Ash	11.1
Sulphur	3.4
Calorific value, B.t.u. per lb.	12,290

[1] Assistant Physicist, U. S. Bureau of Mines. Assoc-Mem. A.S.M.E.

[2] Assistant Engineer, U. S Bureau of Mines. Published by permission of the Director, U. S. Bureau of Mines.

Refractories Temperatures

Forced-Draft Furnace. Temperatures were measured in six firebricks at different places in the north side wall, and in seven tiles at different places in the fire arch. The positions of bricks and tiles are indicated in accompanying Figs. 1, 3, and 4. In one side-wall brick, placed at position 1, and in one arch tile, placed at position 10, temperatures were measured at points $^1/_2$, 1, 3, and 6 in. outward from the surface exposed to fire; in each other brick and tile indicated, temperatures were measured at three points, which were 1, 3, and 6 in. outward from the surface exposed to fire. Points $^1/_2$, 1, 3, and 6 in. from the surface are designated respectively *A*, *B*, *C*, and *D*. Thermocouples of platinum and platinum-rhodium alloy wire were used $^1/_2$ in. from exposed surfaces, and base-metal alloy wires at other places. In all bricks the temperature soon became too high for the latter wires at the *B* positions.

Time-temperature logs for three side-wall bricks and three arch tiles are represented graphically in Figs. 5, 6, and 7. The log of boiler load, taken from meter observations, is plotted on each of these three charts for reference. The charts show a preliminary period of eighteen hours, in which the newly built wall and arch were heated moderately, the boiler not steaming, followed by three days' normal operation, of the furnace and boiler, with intervals when the fire was banked and the boiler off the line. The comparatively short time scale used in plotting these records accentuates the abrupt appearance of temperature changes preceding and following banking intervals. Temperatures observed at 15-minute intervals in the side wall and arch, at positions 1-*A* and 10-*A*, respectively, are plotted in Fig. 8 for the period from 8:30 p.m., March 30, to 11:15 a.m., March 31. These graphs correspond to the graphs 1-*A* and 10-*A* from 33 to $47^3/_4$ hr. as given in Fig. 5, but the extended time scale employed in Fig. 8 reveals small changes in rate of cooling and heating, as well as in the sequence of corresponding changes in side-wall and arch temperatures, which are not apparent on a short time scale.

Temperature gradients through the bricks for any commonly found condition of service, whether equilibrium, cooling, or heating, may be drawn on a graph through any three or more points representing temperatures at different places in the same brick observed simultaneously. Fig. 9 is an example of temperature-gradient curves. It is based on temperatures observed at 1 p.m., March 30, i.e., $25^1/_2$ hr. from the time the fire was started. At this time brick temperatures and the rate of flow of heat through the bricks were increasing, as is shown by the concavity of the curves.

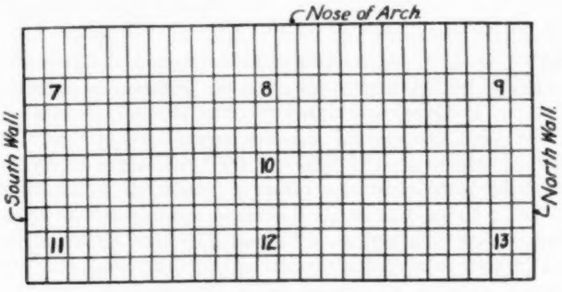

Fig. 4 Main Arch Showing Positions Where Arch-Tile Temperatures Were Measured

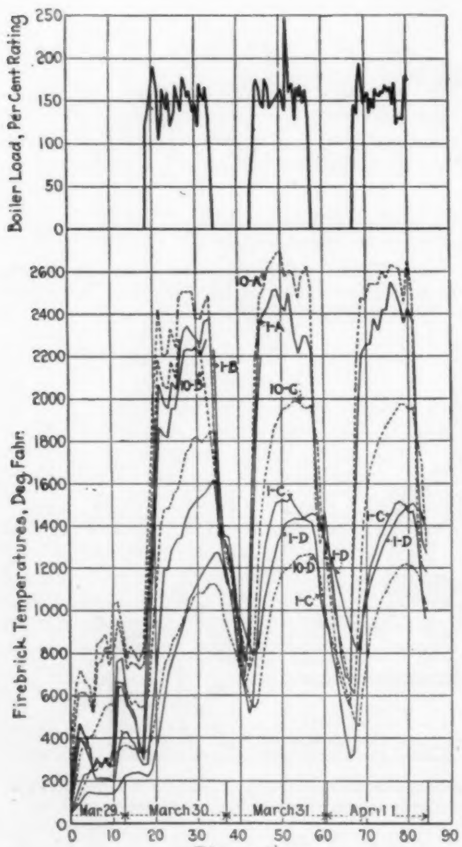

Fig. 5 Time-Temperature Curves, Side Wall and Arch

(Position 1, side wall, 25 in. from coal gate, 12 in. above grate. Position 10, arch, 72 in. from north wall, 24 in. from ignition arch. Distances from surface, A = $^1/_2$ in., B = 1 in., C = 3 in., and D = 6 in.)

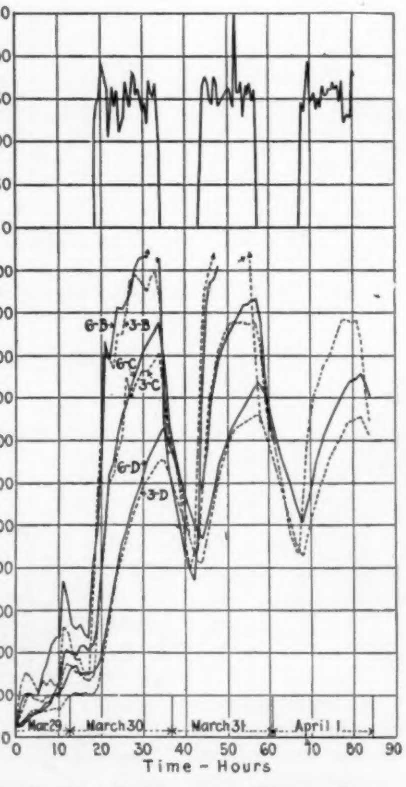

Fig. 6 Time-Temperature Curves, Side Wall, Boiler No. 18

(Positon 3, 25 in. from coal gate, 23 in. above grate. Position 6, 86 in. from coal gate, 28 in. above grate. Distances from surface, B = 1 in., C = 3 in., D = 6 in.)

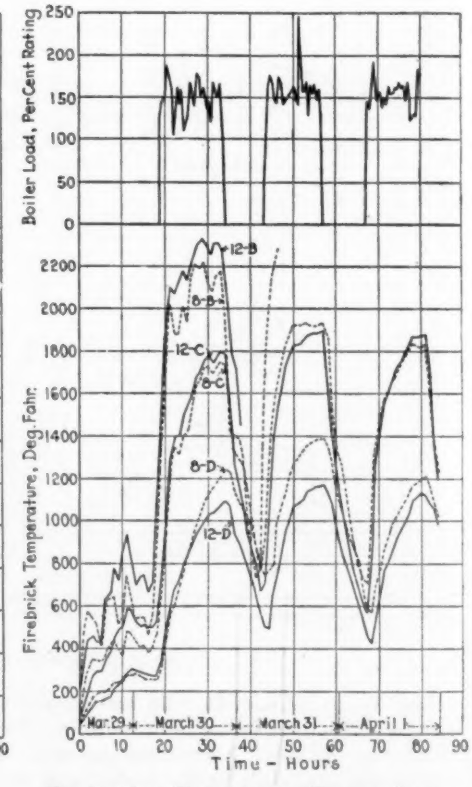

Fig. 7 Time-Temperature Curves, Arch, Boiler No. 18

(Position 8, 6 in. from north wall, $3^1/_2$ in. from ignition arch. Position 12, 6 in. from north wall, $^1/_2$ in. from ignition arch. Distances from surface, B = 1 in., C = 3 in., D = 6 in.)

The curves are extrapolated from $^1/_2$ in. from the surface in brick No. 1 and arch tile No. 10 and from 1 in. from the surface in the other pieces. As there may be an inaccuracy in placing the couple as much as $^1/_8$ in. either way from the given distance from the hot face of the refractory, the extrapolated surface temperature may be in error by plus or minus 50 deg. fahr.

Brick No. 4 was a hand-made Pennsylvania brick, while No. 5 was a dry-pressed Missouri flint brick. Although the conductivity of the two bricks may be considerably different, their surface temperatures would be expected to be very nearly the same as they

were side by side. The unavoidable inaccuracy in placing the thermocouple junctions at exact distances from the surface probably accounts for the apparent temperature differences in the two bricks.

Furnace-Gas Temperature and Composition

The temperature and composition of the furnace gases just inside the wall at the various positions shown in Fig. 2, as determined at three boiler loads, are shown in Fig. 10. Two sets of gas samples taken on two different days and four sets of temperature readings are shown.

It will be noted that there was less than 1 per cent of CO at any position at 120 per cent of boiler rating. At 150 per cent rating as much as 10 per cent CO and 5 per cent H_2, with practically no O_2, occurred at position 1, which as shown in Fig. 2, was just above the fuel bed over the first air compartment. The combustible gases disappeared and the O_2 was much greater at positions 3 and 6 toward the rear of the arch. This was probably caused by air leakage between the ledge plate and the grate.

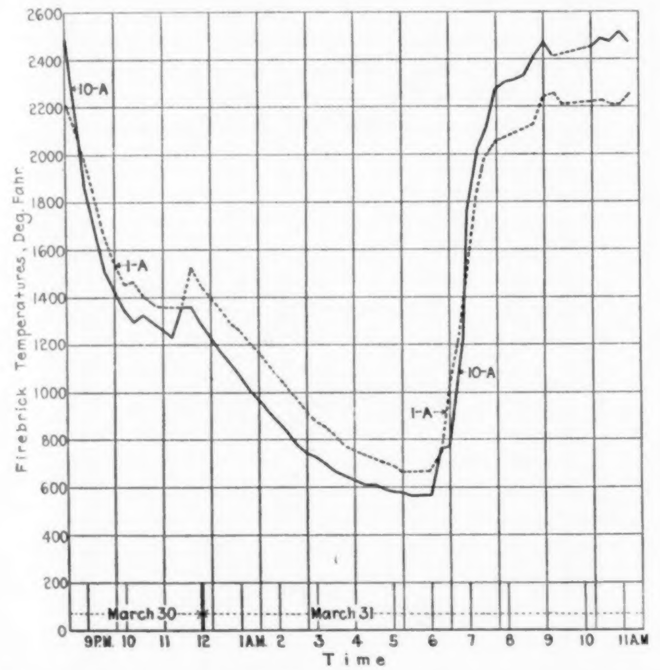

Fig. 8 Time-Temperature Curves, Arch and Side Wall, Boiler No. 18

(Position 1-*A*, side wall, 25 in. from coal gate, 12 in. above grate, 1/2 in. from surface. Position 10-*A*, arch, 72 in. from north wall, 24 in. from ignition arch, 1/2 in. from surface.)

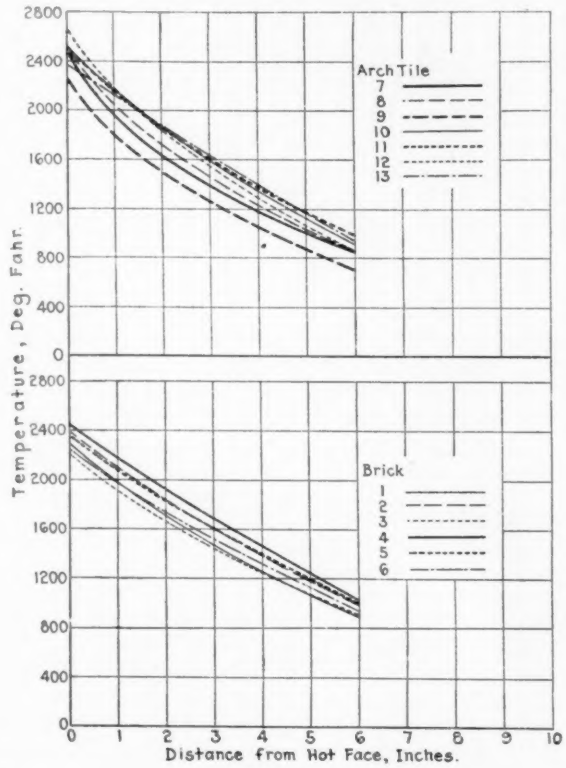

Fig. 9 Temperature Gradient Through Bricks, Pittsburgh Coal on Chain Grate

The combustible content of the gases at position 1 was higher than at other positions at 180 per cent rating, but was less than at 150 per cent. The combustible contents on the middle plane, positions 4, 5, and 6, and the upper plane, positions 7, 8, and 9, were much less than at 150 per cent rating.

The lesser combustible content of the gases at the higher ratings may have been due to increased leakage at the slightly higher furnace draft carried at this rating, to the better mixing because of increased velocity of the gases, or to a difference in the condition of the fuel bed caused by difference in coking rate.

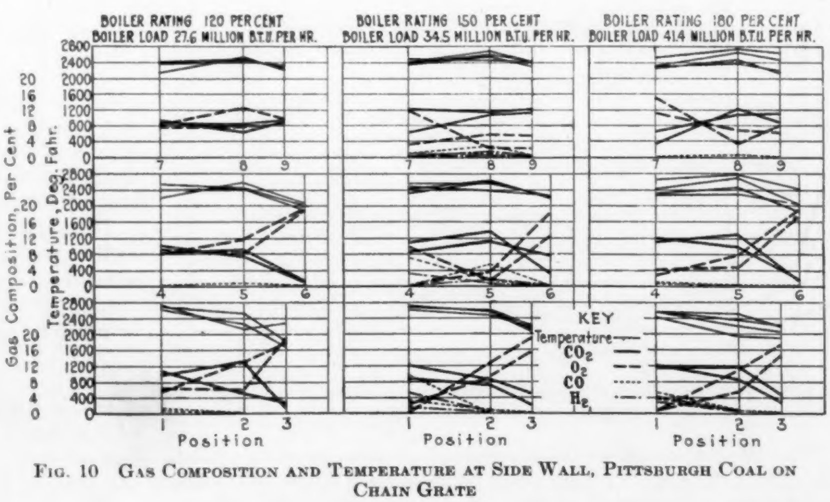

Fig. 10 Gas Composition and Temperature at Side Wall, Pittsburgh Coal on Chain Grate

The gas temperatures at the side wall ranged from 1700 to 2800 deg. fahr., the highest temperatures occurring half-way between the front and rear of the arch, position 5, at 180 per cent rating. The temperatures did not vary greatly with the rating.

Fig. 11 shows the variation in gas composition and temperature across the furnace under the arch half-way between the front and rear, position 8, and at the rear or nose, position 9. The combustible contents were greater than at the side wall, where they were lessened by the air coming up between the ledge plate and grate. The CO was at a maximum 3 ft. from the wall, and as at the side wall was greater at 150 per cent rating than at the lower or higher boiler loads.

The temperatures did not vary greatly across the furnace and did not vary in any regular way with the rating.

Fig. 12 shows the composition of the gases from front to rear of the furnace on the three planes of sampling at 2 ft. from the furnace wall. As only the gases at positions 7, 8, and 9 are near the refractories of the arch, this figure is of more particular interest in connection with the progress of combustion in the furnace. As shown in the previous figures, the CO content of the gases was greater at 150 per cent rating than at the lower and higher ratings.

SO_2 and SO_3 Content of Gases

The SO_2 and SO_3 contents of the furnace gases in weight per cubic foot and in per cent by volume are given in Table 1. Most of the samples were taken 1 in. inside the wall. A few samples were taken at a distance of 6 in. from the wall, immediately after the corresponding sample at 1 in. was taken. It has appeared

TABLE 1 COMPOSITION OF FURNACE GASES, INCLUDING SULPHUR

Sample number	Boiler rating, per cent	Position number	Distance from south wall, in.	Grams per cubic foot of gas SO_2	Grams per cubic foot of gas SO_3	Gas composition, per cent by volume SO_2	SO_3	CO_2	O_2	CO	H_2	N_2
13	120	1	1	0.0747	0.0284	0.099	0.030	9.2	8.5	0.7	0.7	80.8
28	130	1	1	0.1052	0.0326	0.137	0.034	10.1	6.3	0.9	0.4	82.1
14	125	2	1	0.0110	0.0088	0.014	0.011	3.4	17.1	0.0	0.0	79.5
29	125	2	1	0.0121	0.0282	0.016	0.027	4.1	16.7	0.0	0.0	79.2
15	125	5	1	0.0160	0.0086	0.021	0.009	5.3	15.2	0.0	0.0	79.5
30	118	5	1	0.0197	0.0283	0.025	0.031	7.1	13.1	0.0	0.1	79.6
12	127	6	1	0.0065	0.0046	0.009	0.005	0.8	19.6	0.0	0.0	79.6
31	118	8	1	0.0274	0.0795	0.036	0.084	11.2	5.5	0.0	0.0	83.2
10	125	8	1	0.0795	0.0073	0.102	0.008	14.2	1.9	0.7	0.7	82.4
9	130	9	1	0.0920	0.0310	0.119	0.030	11.0	5.7	0.1	0.3	82.8
11	122	9	1	0.0260	0.0223	0.032	0.021	11.4	5.1	0.5	0.3	82.6
32	115	9	1	0.0017	0.0432	0.002	0.044	6.8	13.3	0.0	0.0	79.9
8	155	5	1	0.0014	0.0024	0.002	0.003	5.7	14.7	0.0	0.0	79.6
5	145	6	1	0.0103	0.0041	0.011	0.005	5.3	15.3	0.0	0.0	79.4
6	150	6	6	0.0245	0.0140	0.031	0.012	13.5	3.7	1.1	0.1	81.6
7	145	8	1	0.0454	0.0432	0.062	0.043	13.1	1.7	1.6	0.9	82.6
3	155	9	1	0.0495	0.0168	0.063	0.017	12.4	5.1	0.0	0.0	82.4
1	165	9	1	0.0835	0.0441	0.109	0.045	9.8	8.8	0.0	0.2	81.0
4	160	9	6	0.0649	0.0304	0.086	0.031	13.5	3.2	0.0	0.0	83.2
2	165	9	6	0.0663	0.0828	0.087	0.087	13.3	2.5	1.5	0.4	82.1
22	186	1	1	0.0742	0.0179	0.099	0.019	10.9	0.6	4.2	2.8	81.4
16	188	1	1	0.0943	0.0000	0.124	0.000	10.1	0.4	5.4	5.8	78.2
17	185	2	1	0.0347	0.0279	0.004	0.031	8.1	12.0	0.0	0.0	79.9
23	187	2	1	0.0035	0.0110	0.005	0.013	6.3	13.3	0.0	0.0	80.4
24	175	5	1	0.0162	0.0400	0.021	0.041	13.0	4.9	0.8	0.1	81.1
18	189	5	1	0.0435	0.0266	0.055	0.030	10.8	8.3	0.0	0.0	80.8
27	180	6	1	0.0018	0.0067	0.002	0.009	2.3	18.7	0.0	0.0	79.0
19	190	6	1	0.0088	0.0142	0.012	0.014	2.5	18.3	0.0	0.0	79.2
20	175	6	6	0.0952	0.0242	0.123	0.025	13.9	4.5	0.8	0.4	80.3
25	178	8	1	0.0172	0.0298	0.022	0.029	12.0	3.5	1.3	0.5	82.6
26	192	9	1	0.0075	0.0173	0.010	0.017	12.5	4.5	0.0	0.0	83.0
21	180	9	1	0.0928	0.0295	0.122	0.029	11.4	6.8	0.2	0.1	81.3

from previous work that the ratio of the SO_3 to SO_2 was greater at the wall surface than at some distance away. It was thought possible that the hot refractory surface might have a catalytic action in promoting the oxidation of the SO_2 to SO_3.

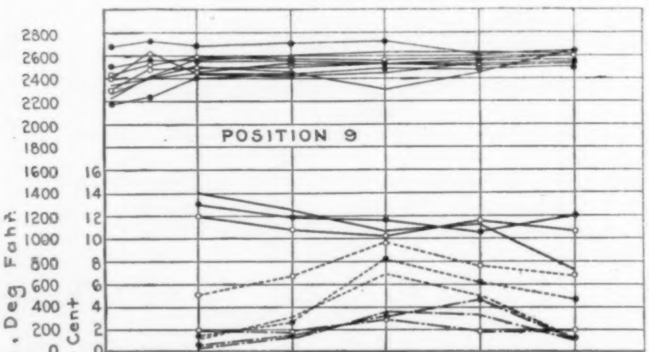

FIG. 11 GAS COMPOSITION AND TEMPERATURE ACROSS FURNACE, PITTSBURGH COAL ON CHAIN GRATE

The present samples offer no conclusive evidence on this point. Samples 1, 2, 3, and 4 were taken at position 9 which is so close to the refractory surface of the arch that no great difference between the samples at 1 and 6 in. from the side wall might be expected. There is no real difference in the SO_3-SO_2 ratio in samples 5 and 6, taken at 1 and 6 in. from the wall at position 6, but in sample 19, taken at 1 in. at position 6, the SO_3-SO_2 ratio was much higher than in sample 20 taken at 6 in. from the wall in the same position.

The SO_2 and SO_3 contents varied greatly for the various positions and for duplicate samples at one position and rating. The SO_2 was considerably greater than the SO_3 at position 1 where the greatest evolution of combustible gases occurred and the SO_3 generally increased further along in the furnace.

VELOCITY OF GASES

The velocity of the furnace gases at the side wall as measured by a pitot tube at the three boiler loads are shown in Fig. 13. The velocities along the lower plane, positions 1, 2, and 3, show no regularity of variation with position or boiler rating, probably

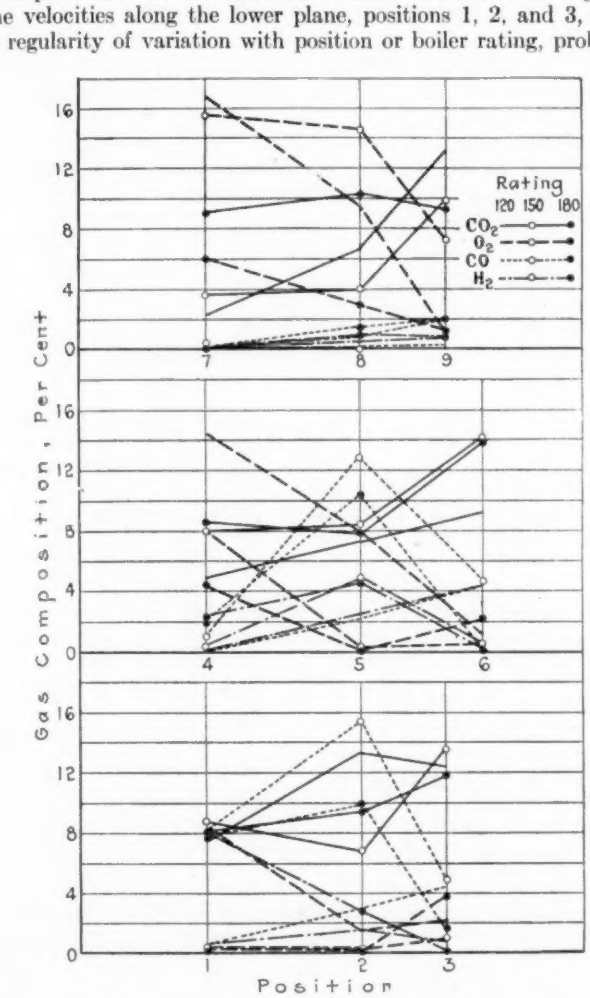

FIG. 12 GAS COMPOSITION IN FURNACE, PITTSBURGH COAL ON CHAIN GRATE

owing to the eddy currents and varying direction of flow just above the fuel bed. They are somewhat more regular on the middle level and on the upper level show a regular increase in velocity from positions 7 to 9. The maximum velocity at the nose of the arch at 180 per cent of rating was about 37 ft. per sec.

The variation in the velocities from 1 in. to 5 ft. from the side wall at positions 7, 8, and 9 are shown in Fig. 14. Except at position 7 where the velocity of the gases is low, often being zero, the velocities increase up to 1 ft. from the side wall, the maximum being 45 ft. per sec.

COAL-ASH AND SLAG COMPOSITION

In the study of the mechanism of slag erosion the compositions of samples of coal ash, ash and refuse, and materials collected in various ways in the furnace have been determined. The analyses are given in Table 2.

The composition of the non-combustible in the ash and refuse, sample 55, closely approaches that of the corresponding coal ash, sample 54. There were significant differences, however, in the sulphur content, which decreased from 2.2 to 0.4 per cent, and in the alkalis content, which decreased from 2.0 to 1.1 per cent. The Fe_2O_3 content also was less in proportion to the SiO_2 and Al_2O_3. This was to be expected since, as pointed out below, the Fe_2O_3 content of the material carried out in the gases was considerably greater than that of the coal ash.

Samples 41, 51, and 52 were taken through a specially designed

TABLE 2 COMPOSITION OF ASH AND SLAG SAMPLES

Sample number	Description	SiO_2	Al_2O_3	Fe_2O_3	FeO	TiO_2	CaO	MgO	K_2O and Na_2O	Sulphur as SO_3	$\frac{SiO_2}{Al_2O_3}$ ratio	Softening temperature	Softening interval	Fluid interval
2	Coal ash	44.0	19.5	26.8		0.8	2.8	0.9	4.0	1.2	2.26	2090	100	150
10	Coal ash	39.6	20.3	32.7		0.9	2.4	0.5	2.4	1.2	1.95	2090	220	170
54	Coal ash	43.4	19.8	28.1		0.8	3.1	0.6	2.0	2.2	2.19	2110	163	127
..	Average of 2, 10, 54	42.3	19.9	29.2		0.8	2.8	0.7	2.8	1.5	2.13	2100		
55	Ashes and refuse simultaneous with 54	46.2	20.7	27.6		0.9	2.5	0.6	1.1	0.4	2.23			
41	Slag collected in slag collector—position 6	30.7	16.6	37.5			1.9	0.6	0.8	6.5	1.85			
51	Slag collected in slag collector—position 6	33.7	18.9	33.3			3.9	0.7	0.9	2.0	1.78			
52	Slag collected in slag collector—position 6	36.7	20.1	34.0			4.8	0.7	0.2	1.9	1.83			
11	Slag collected on sampling tubes—position 6	25.7	14.6	7.2	39.2		2.1	0.2	2.1	8.9	1.76			
12	Slag collected on sampling tubes—position 3	27.6	15.4	6.4	36.7		2.5	0.4	1.6	9.4	1.79			
43	Slag collected on sampling tubes—position 6	21.6	14.0	40.8	21.1		1.1	0.0	0.8	0.6	1.54			
53	Slag collected on sampling tubes—position 6	35.0	16.6	12.6	27.5		3.7	0.2	2.9	1.5	2.1			
21	Slag from boiler tubes	29.6	17.1	46.2	2.9		1.8	0.4	1.8	0.2	1.73	2040	50	140
20	Slag from top of bridge wall	34.4	18.5	40.8	1.7		1.8	0.1	2.5	0.2	1.86	2030	75	150
22	Slag from lower side wall	35.3	30.2	22.2	9.4		1.6	0.2	1.1	0.0	1.17			

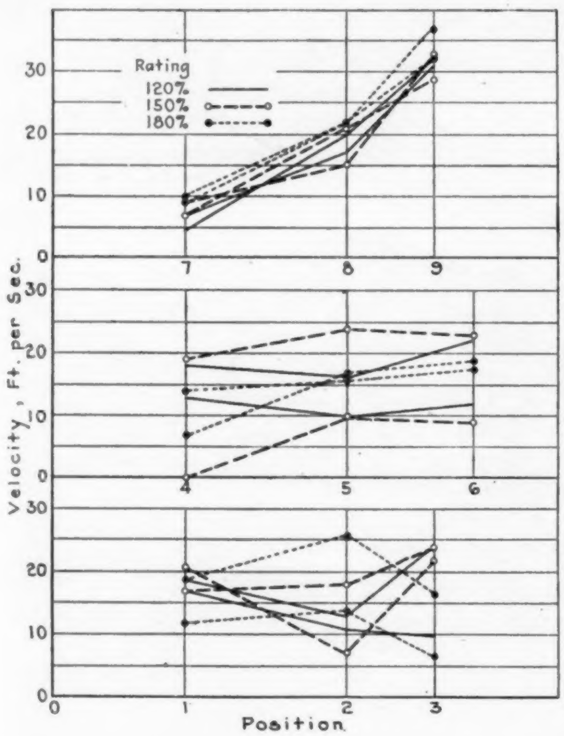

FIG. 13 VELOCITY OF GASES AT SIDE WALL, PITTSBURGH COAL ON CHAIN GRATE

slag collector, which consisted essentially of a water-cooled tube which could be placed in the furnace with the open end facing the direction of flow of the gases. A cyclone-type separator was placed directly on the outer end of the sampler. This efficiently removed the solids other than the soot.

The flow of gases with their accompanying solids into the sampler was established by means of a reduced pressure maintained by a suction pump. The rate of flow, measured by the pressure drop across an orifice, was set so that the linear velocity of the entrance into the sampler was approximately that of the gases through the furnace at the given point. A part of the solids was deposited in the sampler and this was added to that collected in the separator. Since the material collected by this means was immediately cooled and was not subjected to further action of the gases, these analyses should represent very closely the composition of the material in the gases. The samples as collected contained a large amount of soot, therefore, the ferrous and ferric iron could not be determined separately and the iron content is reported as ferric oxide. The analyses are reported on the combustible-free basis.

Samples 11, 12, 43, and 53 were collected on the outside of water-cooled gas sampling tubes. This material collected in the same manner that it collects on the first rows of boiler tubes. Although it was chilled by contact with the tube, the material remained in contact with the furnace gases for the period of sampling (30 min. to 1 hr.) and there was a possibility of change in composition. The ferrous and ferric oxide contents are reported separately.

There was considerable variation in composition among the several samples taken in each of the two ways. The total iron content of the samples collected on the outside of the tubes was higher than that of the samples taken in the collector. This was probably due to the fact that that part of the ash high in iron was in a fused state and adhered to the tubes more readily than that high in silica and alumina. With the exception of sample 43, the ferrous iron content was from two to almost six times greater than the ferric content.

It is notable that the iron contents of all the samples taken in the furnace were greater than that of the coal ash. The increased iron content of the material leaving the fuel bed was also shown in a sample of dust taken from the soot chamber of a similar boiler in the station. The percentage composition of this sample was as follows: Combustible, 14.9; ash, 85.1; Fe_2O_3 in ash, 37.3.

It is also considered significant that the silica-alumina ratio was lower than in the coal ash.

The slag which was found on the boiler tubes was spongy and very friable. It did not adhere readily to the tubes and the top of the bridgewall was covered to a considerable depth with a similar slag, a large part of which had apparently fallen from the tubes. The iron contents of these materials were of the same order as those of the samples taken no the outside of the samplers for the reason given above, namely, that the more fusible material, which was high in iron, adhered more readily to the tubes. Since this slag was maintained at a comparatively low temperature and may have been subjected to oxidizing atmosphere, the ferrous-iron content was low.

The most striking item in the analysis of the slag taken from the lower side wall, sample 22, was the high alumina content and the correspondingly low silica-alumina ratio. This sample consisted of slag which had run over the wall and had thus combined with the refractory. The silica-alumina ratio in the bricks in this wall was approximately 1.0. To obtain this low silica-alumina ratio in the slag it must either have been principally refractory plus the high iron constituents of the coal ash, or the slag dissolved more alumina than silica from the refractories.

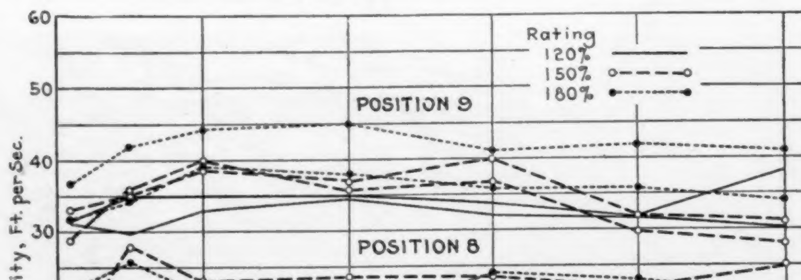

FIG. 14 VELOCITY OF GASES ACROSS FURNACE, PITTSBURGH COAL ON CHAIN GRATE

No information has heretofore been available as to the quantity

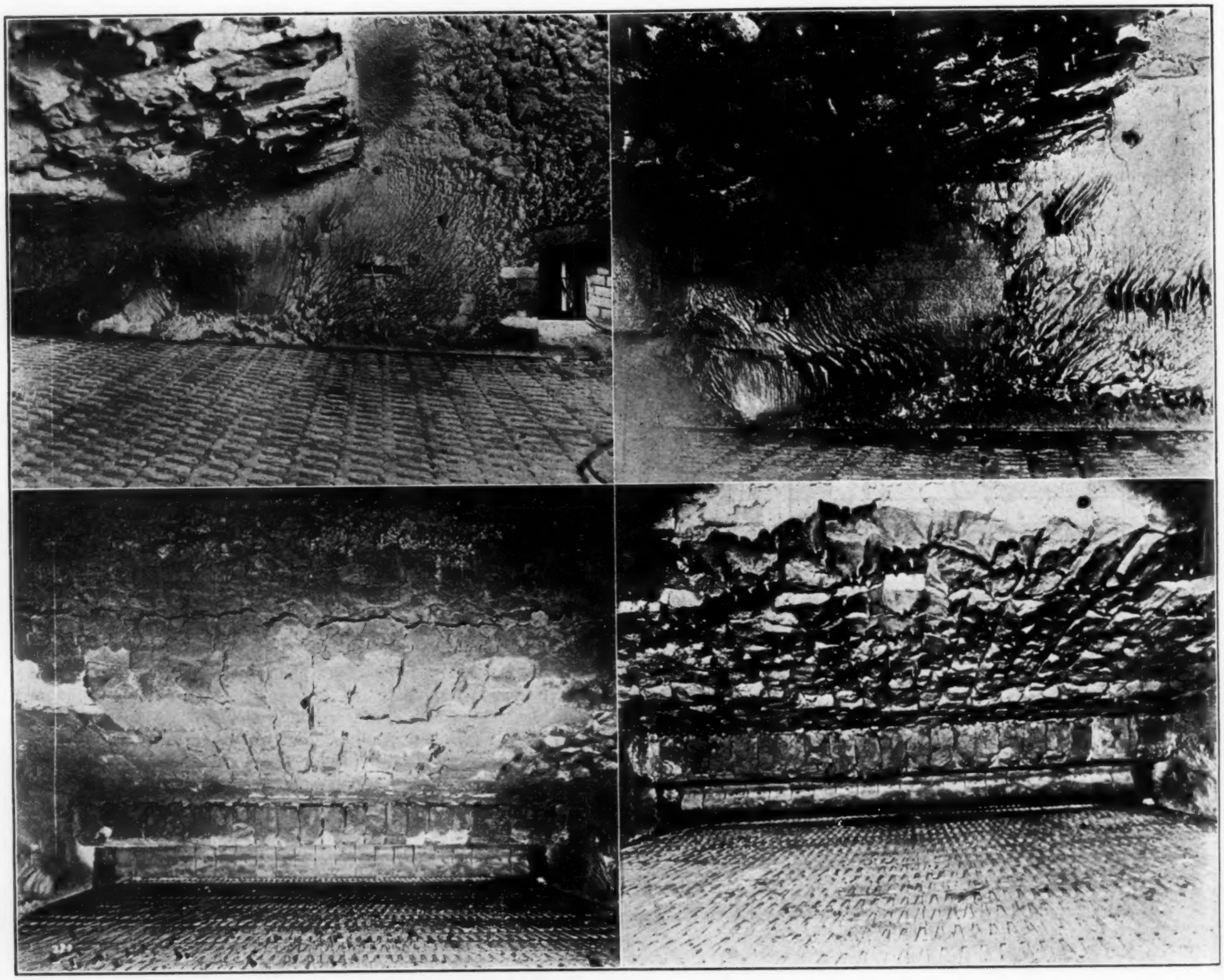

Fig. 15 Views of Forced-Draft-Stoker Furnace

Fig. 16 Views of Induced-Draft-Stoker Furnace

of material carried in the furnace gases to be deposited on the walls. This lack of information has made it necessary for designers of slag tests to choose an arbitrary rate of feeding the slag.

Hoping to supply some information on this point and also to connect the amount of slagging with the quantity of slag, an attempt was made to determine the weight of ash material carried per cubic foot of gas. The sampler and cyclone-type separator described in the preceding paragraphs were used. The material collected was

TABLE 3 QUANTITY OF SLAG CARRIED IN FURNACE GASES

Sample Number	Position	Distance from wall, in.	Boiler rating, per cent	Grams material per 100 cu. ft.	Total lb. per hr.	Per cent total ash
16	6	24	150	3.0	50	12
17	6	24	150	4.6	77	19
18	6	24	180	3.5	72	15
19	6	24	180	1.5	31	6
40	6	18	190	4.8	104	20
41	6	18	190	5.7	121	24
42	6	18	130	2.7	39	11
49	6	1	150	2.5	49	10
50	6	18	150	4.7	79	19
51	6	1	150	2.1	35	9
52	6	18	150	3.7	62	15

ignited, and the results for several samples are given in Table 3.

The grams of material per 100 cu. ft. of cold gas are in fair agreement, except for sample 19. The highest values were found at the highest rating and the values for the samples taken just inside the wall were considerably less than for those at 18 or 24 in. from the wall, as would be expected from their relative velocities.

The item "Total lb. per hour" gives the weight of material in the gases passing through the furnace per hour, calculated from the coal fired and the weight of air per pound of coal, assuming that the gases in all parts of the furnace contained the same amount of material as at the point of sampling. The last item gives the amount of material in the gases as the per cent of total ash fired to the furnace. This varies from 6 to 24 per cent. Excluding the value of 6 per cent, which is much lower than the others, and the 2 values at 1 in. from the wall, the average is 17 per cent.

Using this average value of 17 per cent of the ash carried in the gases and 83 per cent remaining on the grates to obtain a weighted average of the composition of the slag or dust carried in the gases and the ash and refuse for purpose of comparison with the composition of the coal ash, gives the following results:

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O Na_2O	SO_3
Ashes and refuse, 55	46.2	20.7	27.6	2.5	0.6	1.1	0.4
Average of slags, 41, 51, 52	33.7	18.5	34.9	3.5	0.7	0.6	3.5
Weighted average	44.0	20.4	28.8	2.7	0.6	1.0	0.9
Coal ash, 54	43.4	19.8	28.1	3.1	0.6	2.0	2.2

This shows that the increase in iron in the material in the gases is balanced by the decrease in the ash and refuse. The other constituents balance well, except the alkalis and SO_3. This might be expected because of their volatility.

The agreement between the calculated weighted average composition and the determined composition of the coal ash is surprisingly close when the method used is considered. The rate of taking the samples was but about 60 cu. ft. per hr., while the rate of flow of air through the furnace was from 600,000 to 1,000,000 cu. ft. per hr. and the total weight in any sample did not exceed 6 grams.

REFRACTORIES SERVICE

Forced-Draft Stokers. This furnace was relined with new bricks before the tests were started with the exception of the two front courses of tile in the main arch and the ignition arch. One wall was laid with a hand-made Pennsylvania brick and the other with a steam-pressed Missouri flint-clay brick. The arch tile were made in the Missouri field.

The boiler was in service from March 30 to April 16, inclusive, and during this period steamed 237 hr. and was banked 219 hr., or a banking to steaming ratio of 0.92. The half-hour maximum rating was 250 per cent, while the average for all steaming hours was 140 per cent. The average daily load-factor ratio of daily average to daily maximum was 0.69 for this period.

The furnace was inspected and photographed on April 17. The arch and portions of the side walls are shown in the lower left-hand picture in Fig. 15. The first four rows of the fire arch had spalled very little, but it was estimated that about two-thirds of the blocks in the rest of the arch had spalled and the pieces dropped off. It was found by sounding with a hammer and inspection at the sides that nearly every block in this part of the arch was cracked and the pieces were being held in only by the adhesion of the slag to adjacent blocks. Although there was a coating of slag on the blocks and small stalactites of slag hanging from them, there was little or no erosion by slag noted.

The sidewalls were eroded by slag, as can be seen from the photograph, starting from 18 to 24 in. from the coal gate in a narrow but deep zone, and increasing in width but decreasing in depth toward the rear of the furnace. The maximum depth of erosion was approximately 4 in There was no measurable difference between the Pennsylvania brick which are in the left-hand wall of the photograph and the Missouri brick which are in the right-hand wall.

The lower right-hand photograph of this figure was taken May 30 and shows how the spalling has progressed, pieces having then broken and fallen from all the arch tiles with the exception of the first three or four courses.

The photograph in the upper left-hand of Fig. 15 is that of the south side wall of the furnace, taken on May 2, at which time the boiler had steamed for 367 hr. after the tests were started, with an average daily load factor of 0.695. This view shows the slag erosion in detail. The holes through the wall are those for the introduction of gas-sampling tubes and thermocouples. The grooving below several of the holes was caused by the iron oxide formed by the burning of the end of the iron nipples through the wall fluxing with the refractory.

Reference to Fig. 10, giving the gas composition and temperature at the side wall, shows that the area of greatest erosion on the side wall was coincident with the area of maximum content of combustible gases, and high gas temperatures. Reference to Fig. 9, giving the temperature gradients through the walls, shows that the temperature at the surface of brick No. 1, which was in this area of severe erosion, was not as high as that of bricks Nos. 2, 4, or 5, where the erosion was less severe.

It appeared, therefore, that the severe erosion was probably owing to the high temperature and high combustible content of the gases. There was ordinarily not sufficient oxygen present in the gases in the area, at ratings of 150 per cent or greater, to burn the CO and H_2. It was conceived that if air could be introduced in this zone which would eliminate the reducing gases and lower the temperature, the erosion might be reduced or eliminated.

Accordingly a system of piping was installed leading from below the damper in the first air compartment of the stoker, through the side wall at the ignition arch, terminating in a 1-in. diameter pipe flush with the inner surface and pointing toward the zone of erosion. The pipe was protected from burning as it did not extend beyond the nose of the ignition arch. An orifice was placed in the pipe to measure the amount of air supplied.

Each side wall from grate to arch and for approximately $4^1/_2$ ft. from the front of the furnace was laid with new hand-made brick from the Pennsylvania field.

Gas samples were taken at position 1, 1 in. inside the wall, with the air off and on. The rate of flow of air was approximately 17 cu. ft. per min., corresponding to a linear velocity at the entrance into the furnace of 48 ft. per sec. The boiler was steaming at from 160 to 180 per cent of rating. The composition of the gas samples was as follows:

	Air off	Air on	Air off	Air on	Air off	Air on
CO_2	12.3	11.1	9.7	10.8	7.7	9.7
O_2	0.0	0.1	0.1	0.5	9.7	4.9
CO	7.7	8.8	11.9	8.5	1.3	4.7
H_2	3.5	4.3	4.7	4.5	0.9	1.9
N_2	76.5	75.7	73.6	75.7	80.4	78.8

It was obvious that the air was not entering the furnace at sufficient velocity to be carried into the gas stream where it was desired. As this was the maximum air flow that could be secured unless the compressed-air service lines were used, it was decided to increase the quantity and velocity of the air admitted by means of a steam injector. An injector was improvised of pipe fittings using a $^1/_8$-in. pipe as the steam nozzle.

The following gas samples were taken with and without the air and steam turned on, the boiler operating at 160 to 180 per cent of rating.

	Air and steam off	Air and steam on[1]	Steam on[2]	Air and steam off	Air on[3]	Air and steam on[4]	Air and steam on[5]
CO_2	14.3	9.4	14.3	14.2	13.6	8.7	11.7
O_2	3.1	9.5	2.9	2.9	0.1	9.5	5.6
CO	1.5	0.0	1.1	0.3	3.5	0.0	0.5
H_2	0.3	0.0	0.5	0.7	1.6	0.0	0.3
N_2	80.8	81.1	81.2	81.9	81.2	81.8	81.9

[1] Steam pressure 10 lb. Air flow 24 cu. ft. per min. [2] Steam pressure 10 lb. [3] Air flow 16 cu. ft. per min. [4] Steam pressure 10 lb. Air flow 23 cu. ft. per min. [5] Steam pressure 5 lb. Air flow 17 cu. ft. per min.

The gas temperatures at distances of from 1 to 6 in. from the wall were as follows:

Distance, in.	1	2	3	4	5	6
Air and steam off	2167	2295	2380	2395	2395	2338
Air and steam on[1]	1897	2053	2096	2139	2338	2636
Steam only on[2]	2309	2238	2295	2366	2608	2594

[1] Steam pressure, 10 lb. Air flow, 22 cu. ft. per min. [2] Steam pressure, 10 lb.

The air flow secured with 10 lb. steam pressure on the injector reached the point of sampling and eliminated the reducing gases. The steam alone or 5 lb. steam pressure with air had little effect on the gas composition.

The gas temperatures were reduced from 200 to 300 deg. up to 4 in. from the wall with the air flow secured with 10 lb. steam pressure. The steam alone with no air had no apparent effect on the gas temperatures.

The boiler was operated from May 6 to May 29, inclusive, under normal conditions, the firemen having instructions to turn on the steam and air at all times when the boiler was steaming.

The photograph in the upper right of Fig. 15 shows the wall as it appeared on May 30. The path of the air and steam from the pipe opening in the ignition arch can be followed by the line of congealed slag extending downward to the right of the ignition arch. The point of sampling the gases and measuring the temperatures given above was the lower rectangular opening at the left of the photograph. The erosion was not eliminated and was apparently not reduced just above the grate. The area of erosion was, however, limited, the upper line being horizontal instead of rising toward the rear of the arch. It is probable that had the air-steam nozzle been pointed more sharply downward toward the grate, a greater effect might have been had in reducing the erosion.

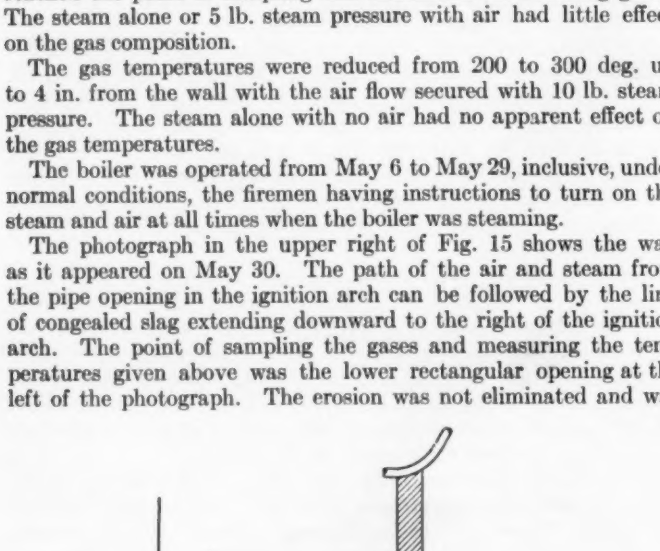

Fig. 17 Boiler Furnace No. 78, Showing Bricks in Which Temperatures Were Measured

It cannot be definitely stated whether the effect was caused by the oxidizing atmosphere obtained, or by the reduction in gas temperature. Perforated blocks laid in this area of the wall connecting with a duct under air pressure might be successful in obtaining a similar end but the slag would probably congeal over the air openings and reduce the amount of air admitted. A large area of such blocks might also too greatly increase the excess air.

The admission of air through the pipe in the ignition arch had the advantage that it did not become stopped and the air supply could be controlled. The steam consumption of the injector was approximately 70 lb. per hr. A better injector effect with less steam consumption could probably be secured with a properly designed steam nozzle.

Induced-Draft Stokers

The more intensive study was made of the forced-draft stoker furnaces at this station but observations were made on other equipment as the opportunities arose. It was stated above that spalling was a serious factor in the refractories failure on the side walls of the induced-draft furnaces. The upper photograph of Fig. 16 shows the condition of one of these side walls after approximately four months' service.

Temperatures were measured in two bricks placed in the wall of No. 78, as shown in Fig. 17. Fig. 18 is a graph of observed temperatures in these two bricks. The curves show a period of eighteen hours for heating the newly built wall, and four days' normal service, with two intervals when the fire was banked over night. Cooling and heating curves of the banking period following the second day of service are plotted on an extended time scale in Fig. 19. The extended curves give a good picture of the sequence of temperature changes at different points in each brick.

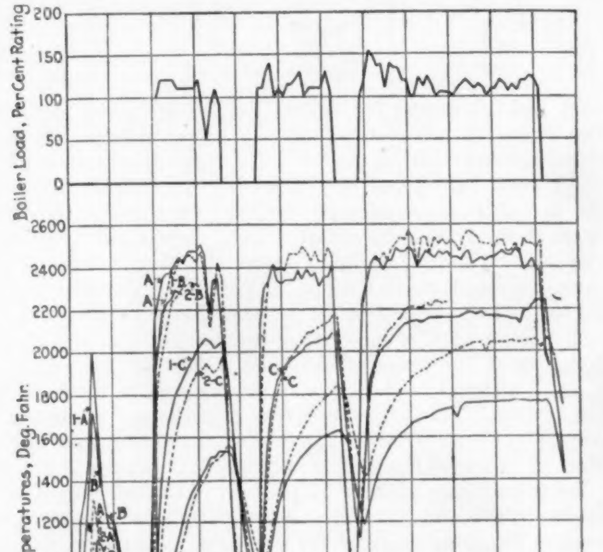

Fig. 18 Time-Temperature Curves, Side Wall, Boiler No. 78
(Position 1, 34 in. from coal gate, 11 in. above grate. Position 2, 94 in. from coal gate, 30 in. above grate. Distances from surface, A = 1/2 in., B = 1 in., C = 3 in., D = 6 in.)

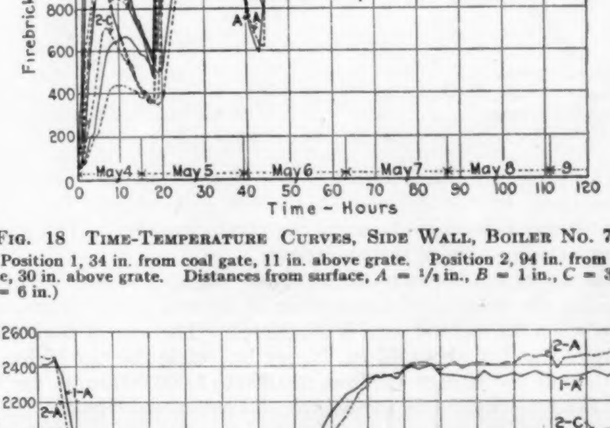

Fig. 19 Time-Temperature Curves, Side Wall, Boiler No. 78
(Position 1, 34 in. from coal gate, 11 in. above grate. Position 2, 94 in. from coal gate, 30 in. above grate. Distances from surface, A = 1/2 in., C = 3 in., D = 6 in.)

The lower photograph of Fig. 16 shows this wall after four weeks' service. It is interesting to note that there is no spalling apparent on the surface of this wall. Sounding the wall with a hammer showed it to be unsound toward the rear of the furnace. Spalling had started but the pieces were still held in place by the pressure of adjacent pieces and the slag coating.

Research on Oil-Injection Engines for Aircraft

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This paper discusses the problem of the high-speed, high-capacity oil-injection engine and describes some of the apparatus used and some of the results obtained in the fundamental studies conducted on oil sprays injected into compressed gases by means of ultra high-speed motion-picture photography; researches on injection hydraulics and on oil characteristics; special bench tests of injection valves, pumps, and miscellaneous fuel-injection equipment; and engine tests at high speed carried out at the Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics at Langley Field, Virginia.

THE LIMITATIONS of the present type of Otto-cycle aircraft engine as to the maximum efficiency it may attain, and the narrow range of fuels it is capable of using, open the aeronautic-engine field to engines operating on other cycles. Among several types of internal-combustion engines that have been considered, that using a combination of the Otto and Diesel cycles, the Sabathe or dual cycle, has inherent characteristics that remove the limitations of the carburetor engine.

There are three major advantages in using the dual cycle for aircraft engines. First, it uses high compression ratios, thus permitting high thermal efficiencies to be attained. An airship or airplane may thus have a higher rating in ton-miles and, therefore, whether used for military or commercial purposes, produce greater returns for the same fuel weight. Second, the dual-cycle engine may use various kinds and grades of fuels, particularly the heavier fuels, which results in considerably decreased costs and greater freedom in fuel selection. An important advantage of this feature for aircraft is the use of fuels of low volatility, which greatly reduces fire hazards. Third, the dual-cycle engine gives exceptionally low fuel consumption at part load. Thus, aircraft, equipped with dual-cycle or oil-injection engines operating at high compression ratios, will have considerably increased cruising ranges over those equipped with carburetor engines.

Problems Introduced by the High-Speed Aircraft Oil-Injection Engine

The high-speed aircraft oil-injection engine, however, introduces new and entirely different problems from those of the carburetor engine. These problems, though difficult of solution, as evidenced by the present lack of satisfactory performance of all the various engines now in operation, are not in any way insurmountable. Generally speaking, these are problems in design and materials, injection hydraulics, complete preparation and distribution of the fuel during injection, and in the efficient control of the ignition and the combustion. Attention is called to the fact that all the problems of the usual heavy, low- and medium-speed oil-injection engine are considerably intensified and some new problems introduced by the combination of high speeds, high mean effective pressures, low fuel consumption, and light weight required of aircraft engines.

A discussion of all the problems of the high-speed oil-injection engine cannot be given in a paper of this length. Indeed, so little is known about the details of the injection hydraulics of fuels at high pressures, velocities, and temperatures, and about the actual processes of high-speed vaporization, ignition, and combustion that, in many instances, the specific problems have not as yet been discovered. The early ignition, and the complete combustion of the fuel early in the power stroke are, at present, the major problems of the aircraft oil-injection engine and will be briefly discussed.

The oil-injection engine differs from the ordinary aircraft engine in three main particulars. First, the fuel is injected into the engine cylinder under high pressure just before top center, instead of taking it in mixed with the air on the suction stroke. Second, ignition of the fuel is by means of the heat of compression, instead of by electric spark. Third, the oil-injection engine usually operates at higher cylinder pressures.

Ignition

In order to obtain ignition of the injected fuel without the use of hot surfaces, compression pressures of the order of 280 lb. per sq. in. or over must be used. It has been found by experience that these compression pressures give sufficiently high temperatures under operating conditions to cause auto-ignition of Diesel fuel oil. Higher compression pressures, of the order of 380 lb. per sq. in., are required for cold starting. The method of injecting the oil into the engine cylinders, the degree of atomization, spray velocity, and turbulence, control to a very large extent the time required for ignition of the fuel after its injection. If the temperatures in the engine cylinder are comparatively low, and the atomization and rate of distribution, particularly, are poor, considerable time will be required.

It is necessary to complete the injection of the fuel within from 30 to 40 deg. of crank angle to prevent late burning on the power stroke. For an engine running at 1800 r.p.m. this is equal to approximately 0.003 to 0.004 sec., and it may be readily understood that, unless ignition takes place within this brief time, the whole charge of fuel will be in the cylinder at the time combustion is initiated. In engines designed to obtain complete combustion early in the power stroke, in which all the air in the cylinder is available for combustion as injection takes place, this condition leads to practically constant-volume combustion of the whole fuel charge, and results in excessively high cylinder pressures, easily equal to from three to four times the compression pressure. The fuel must be so fully prepared, therefore, before and during injection that ignition will take place practically instantaneously. It is by this means only that complete and the most efficient control of combustion and cylinder pressures will be obtained.

In order to obtain a clearer picture of the problem of obtaining early auto-ignition, let us assume that we have an oil-injection engine operating at full load and 1800 r.p.m. and let us follow a fuel particle across the cylinder until combustion is initiated. As the fuel particle leaves the injection valve its temperature will normally be approximately 100 to 200 deg. fahr., depending upon the design of the injection valve and other engine temperatures. The temperature of this fuel particle must be successively raised until it reaches its auto-ignition temperature, which will be from 400 to 900 deg. fahr., depending upon the fuel. If we may consider this increase in temperature to take place in steps, we then have the first stage of temperature increase taking place, due chiefly to contact with the highly heated air in the cylinder, from about 150 deg. fahr. to the temperature at which the fuel begins to vaporize. This may be called the heat of the liquid. The second stage of heat absorption is during vaporization, in which a sufficient amount of heat is required to satisfy the composite latent heat of the fuel. The third stage is from the vaporization temperature up to the auto-ignition temperature, the vapor now being superheated. As the vapor reaches the auto-ignition temperature, combustion begins and, depending upon the mixture strength at the particular point under consideration, proceeds either slowly or rapidly. The approximate percentage of heat required for a light grade of Diesel fuel oil for the heat of the liquid 45 per cent, for vaporization 35 per cent and for vapor superheat 20 per cent.

Actually, the temperature increases of the fuel particle do not take place in steps as we have assumed. As the particle begins its flight across the combustion chamber its front surface comes into violent contact with the highly heated air, and, aided by the heat of friction, as in the case of the meteorite, heat is absorbed and produced there faster than it can be conducted away, thus resulting in actual vaporization, while the rest of the particle is still relatively cool. This vapor is torn off by impact with the air, as it is formed, and probably left behind to take on more heat, until the auto-ignition temperature is reached. The remainder of the particle continues on, its temperature being continually increased and its size decreased. These processes are further considerably complicated by the fact that ordinarily each particle, as it is forced from

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the main fuel jet, is traveling in very close proximity to hundreds of other particles, that it is probably rotating and presenting new surfaces to the hot air, and that turbulence and radiation have pronounced effects upon its vaporization. Thus, while the three above-mentioned stages of temperature increase are taking place practically simultaneously, it may be seen that, for any one molecule, a considerable time may be necessary before it will be completely separated from the fuel particle and the auto-ignition temperature attained.

The reported time lags for ignition under average conditions in several low- and medium-speed oil-injection engines range from 0.002 to 0.040 sec., the average ignition lag being 0.020 sec. This ignition lag is not permissible in aircraft oil-injection engines, because all the fuel would be in the cylinder when ignition occurred and would be subject, therefore, to constant-volume combustion. Cylinder pressures ranging up to 1200 and 1600 lb. per sq. in. result from such late ignition in high-speed engines, and have been substantiated by actual measurement. The maximum permissible ignition lag for aircraft oil-injection engines designed to obtain complete combustion early in the power stroke and operating at 1800 r.p.m. is not over 0.0007 sec.

Some of the factors that affect the ignition lag are the method of injection, the injection pressure, the spray velocity, degree of atomization and distribution, the fuel characteristics and the initial fuel temperature, the cylinder air temperatures and pressures, the amount of turbulence, and the amount of radiation from hot surfaces in the combustion chamber. If these factors are properly correlated and controlled, the lag of auto-ignition can be minimized and the maximum cylinder pressures controlled to within a few per cent of the compression pressure by varying the rate of injection of the fuel.

Combustion

The problem of obtaining complete combustion of the fuel may be attacked by two methods of engine design. The first method, now being used in many slow- and medium-speed engines, employs partial combustion in a precombustion chamber, followed by practically complete combustion during the power stroke in the engine cylinder. Partial combustion and hence the maximum pressures obtained are controlled by the amount of the clearance volume in the precombustion chamber. Thus, the amount of air present may be sufficient to support complete combustion of only a small part of the fuel charge or to support partial combustion of a greater portion of the fuel charge. In either case the pressure rise in the precombustion chamber can be controlled by design to a very small figure. The remainder of the fuel is partially or completely vaporized by the heat liberated by this partial combustion. The gases and fuel vapors then pass through one or more holes, designed to produce turbulence, into the cylinder to complete the combustion during the power stroke.

This method results in delaying the combustion of some of the fuel throughout the whole of the power stroke, and even in the loss of some fuel during the exhaust stroke, since the partially burned and vaporized fuel in the precombustion chamber is continuously discharged to the cylinder throughout these strokes. For high-speed engines, and particularly for high brake mean effective pressures, the amount of late burning is considerably increased and the combustion efficiency therefore decreased.

The second method of design, also in considerable use, and in which the lag of auto-ignition is of importance, employs a combustion chamber containing all or as much of the clearance volume as practical design will permit. The fuel is injected, therefore, into all or nearly all the air in the cylinder, thus making complete combustion possible early in the power stroke. The kind of combustion obtained by this method depends primarily upon the ignition lag, the timing and rate of injection, the fit between the combustion chamber and the spray, and the timing, amount, and kind of turbulence employed. Assuming the lag of ignition to be sufficiently small for the engine speed, the amount of Otto-cycle combustion will be small and the rate of combustion during injection and the cylinder pressures, therefore, can be largely controlled by the rate of fuel injection. The problems of this type of engine are then resolved into the distribution of the spray, the combustion-chamber shape, and turbulence.

Types of Combustion Chambers

There are four types of combustion chambers to be considered. The first two are without any special turbulence: one in which the fit between the combustion chamber and the spray is poor; the other in which it is good. The third and fourth types employ turbulence, which is defined, as used in this paper, as orderly air movement in the cylinder, controlled in both direction and velocity and as to the time it is produced. The third type of combustion chamber is one in which the fit between combustion chamber and spray is poor; the fourth in which it is good.

The non-turbulent, non-spray-fitting combustion chamber will give efficient combustion for only relatively light loads and low speeds, and has no place in aircraft-engine service.

The non-turbulent combustion chamber, specially shaped to fit the spray used, will give good performance at low speeds, as proved by the large-size, slow-speed engines now in use. Complete distribution of the fuel throughout the combustion chamber, obtained by correct design and the energy of the spray, may take place in a sufficiently short time for efficient combustion in slow-speed engines, but in high-speed engines there is little time for the fuel to reach all the air in this manner. Combustion of the first portion of the fuel charge creates a flame wall at the edges of the spray, heat radiation vaporizes some of the fuel, thus resulting in a decrease of its penetrating powers, the pressure wave tends to check the advance of the spray, and the partial separation of the latter portions of the fuel spray from the air by the burning gases lowers the combustion efficiency for high speeds and high mean effective pressures. Without definite turbulence the fuel-air mixtures at the spray edges will be lean and at the center of the spray it will be rich, thus resulting in inefficient and unbalanced combustion.

The third type of combustion chamber employs turbulence, but the fit between it and the fuel spray is relatively poor. If the air movement is well directed and sufficiently high in velocity, it is possible to mix the fuel and air completely and early enough to secure complete efficient combustion, even in high-speed engines. In order to obtain high mean effective pressures at high speeds, however, the energy to produce the degree of turbulence required will decrease the net power output. In addition, the high gas velocities increase the heat loss through the piston and cylinder walls, and may cause a considerable decrease in mechanical efficiency. Experience has shown that the total losses in this type of combustion chamber may equal or exceed the gain obtained in combustion efficiency.

The last type of combustion chamber, employing turbulence and designed to fit the spray, is best suited for high-speed, high-capacity oil engines. The design of this type of combustion chamber should result in a shape corresponding to the general form of the spray, and, with the piston, should be capable of producing the turbulence required. In order to obtain the most efficient combustion of the fuel at high speeds and high mean effective pressures, the general design, the timing, and degree and direction of the turbulence should effect complete mixing of the fuel with all the air during the injection period. The full attainment of these conditions, together with proper fuel preparation, and ignition and injection control, will result in complete combustion early in the power stroke without excessive cylinder pressures and place the performance of the high-speed oil-injection engine well above that of any other known type.

Investigational Program of National Advisory Committee for Aeronautics

The oil-injection engine activities of the National Advisory Committee for Aeronautics deal primarily with the design and construction of special laboratory apparatus for the investigation of hydraulics and of the characteristics of fuels, with researches on oil sprays in dense gases by means of high-speed motion-picture photography, with researches on the performance of injection valves, pumps, and miscellaneous oil-injection equipment, with tests of cylinders, cylinder heads, and oil-injection systems on single-cylinder test engines, and with theoretical analyses. The goal of this work is fundamental and experimental information leading to solutions of the efficient injection, vaporization, distribution, and combustion of fuel oils within the cylinders of aircraft engines. It should be noted that standard aircraft parts, such as pistons, connecting rods, valves and valve gear, engine bases, and cylinders and cylinder

heads are used in this work, except where increased compression ratios and combustion-chamber shapes have necessitated the construction of new parts.

The objects of the various researches conducted on oil sprays injected into compressed gases by means of ultra high-speed motion-picture photography are to determine the effects of injection-valve design, injection pressure, and the pressure of the gases into which the oil is injected on all of the characteristics of oil sprays. Thus, the development of single sprays with time, their velocities, penetrations, distribution, form, spray cone angles, actual volumes, and relative atomization are determined for various types and designs of injection valves and operating conditions. The injection valves studied include mechanically operated valves with simple round orifices, and automatic injection valves specially developed for high-speed operation.

The oil sprays are produced by discharge through simple round orifices, by impact of simple jets on directing surfaces, by several small orifices in nozzle tips, and by discharge through small or relatively large-diameter annuli. Oil sprays having narrow and wide cone angles, being either solid, tubular, or hollow cones, as produced by the valve seats, guiding surfaces, or high centrifugal force in the oil jet, are studied.

Fuels of various kinds and grades are used in this work and the

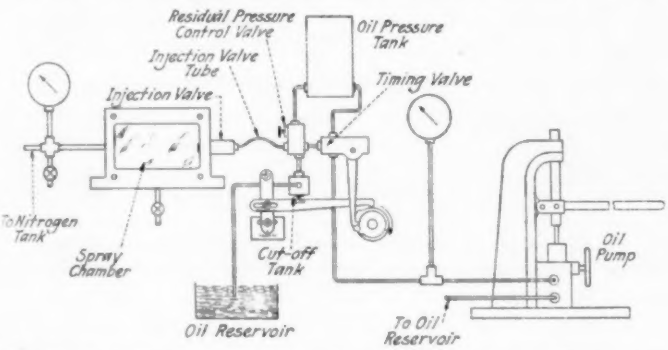

Fig. 1 Diagrammatic Arrangement of Apparatus for Production and Control of Spray

effects of gas density and viscosity studied by using various gases in the spray chamber. The effect of injection pressures up to 10,000 lb. per sq. in. and gas pressures up to 600 lb. per sq. in. are investigated.

Photographic Method of Study

In order to obtain a series of pictures of the growth of a single oil spray having a velocity of 400 to 500 ft. per sec., the duration of the illumination for each picture must be extremely brief and the pictures taken in rapid succession. This is accomplished by discharging twenty-five high-tension condensers in rapid succession across a spark gap in a reflector. The duration of the illumination provided by each spark is of the order of one-millionth of a second and the sparks follow each other at a rate of 4000 per sec. The complete oil spray, thus illuminated, is photographed, at progressive stages in its development, on a film also moving at high speed.

A diagrammatic sketch of the apparatus for the production and control of the oil sprays is shown in Fig. 1. After the condensers are charged, and all test pressures and speeds of the several rotating units of the equipment are obtained, a lever, not shown in the sketch, is tripped and a single spray is injected into the spray chamber. At the same time a master switch is closed and the high-tension condensers discharged through the spark gap to illuminate the spray. Fig. 2 is a reproduction of the development of a non-rotating oil spray from a 0.022-in. round orifice for spray-chamber pressures up to 600 lb. per sq. in. and an injection pressure of 8000 lb. per sq. in. Fig. 3 is a reproduction of the development of a rapidly rotating spray from a 0.040-in. round orifice and for the same spray-chamber and injection pressures. The characteristics of the sprays and the effects of chamber pressure and of injection-valve design are thus accurately and rapidly determined. Fig. 4 shows the pronounced effect of the helix angle of the grooves on the stem that produce the rotation of the oil jet on the characteristics of centrifugal sprays. By means of such photographic records of oil sprays, produced by various injection-valve designs and different pressure conditions, and by the graphs developed from them, the characteristics of oil sprays may be studied from many viewpoints, and the injection of oil into the cylinders of high-speed engines perfected.

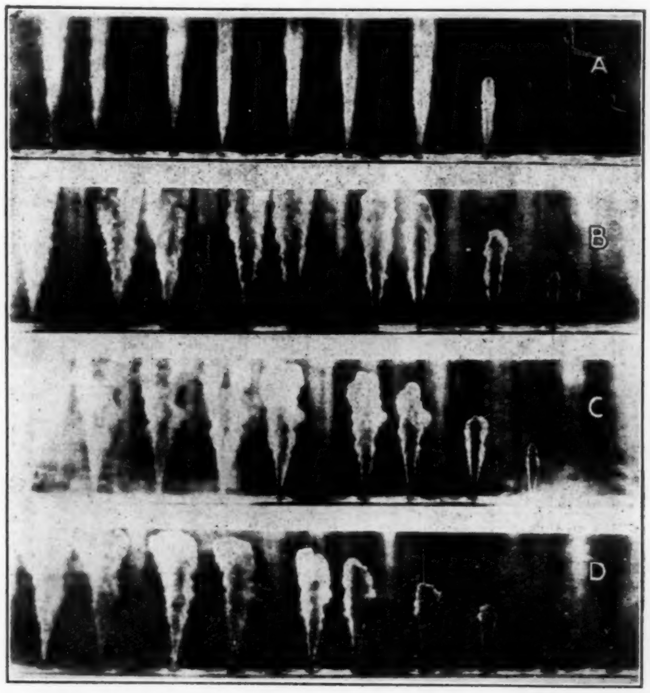

Fig. 2 Oil Sprays from a 0.002-In. Round Orifice at 8000 Lb. Per Sq. In. Injection Pressure. No Jet Rotation

A. Chamber Pressure, Atmospheric.
B. Chamber Pressure, 200 lb. per sq. in
C. Chamber Pressure, 400 lb. per sq. in.
D. Chamber Pressure, 600 lb. per sq. in.

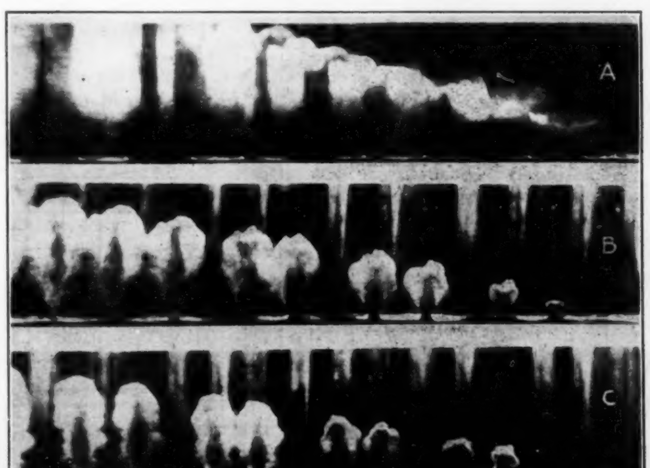

Fig. 3 Oil Sprays from a 0.040-In. Round Orifice, 8000 Lb. Per Sq. In. Injection Pressure. High Jet Rotation

A. Chamber Pressure, Atmospheric.
B. Chamber Pressure, 200 lb. per sq. in.
C. Chamber Pressure, 400 lb. per sq. in.
D. Chamber Pressure, 600 lb. per sq. in.

Discharge of Fuels Through Small Round Orifices

In the design of injection valves it is necessary to know the discharge characteristics of fuels and orifices in order to select an orifice size capable of discharging enough fuel under the pressure em-

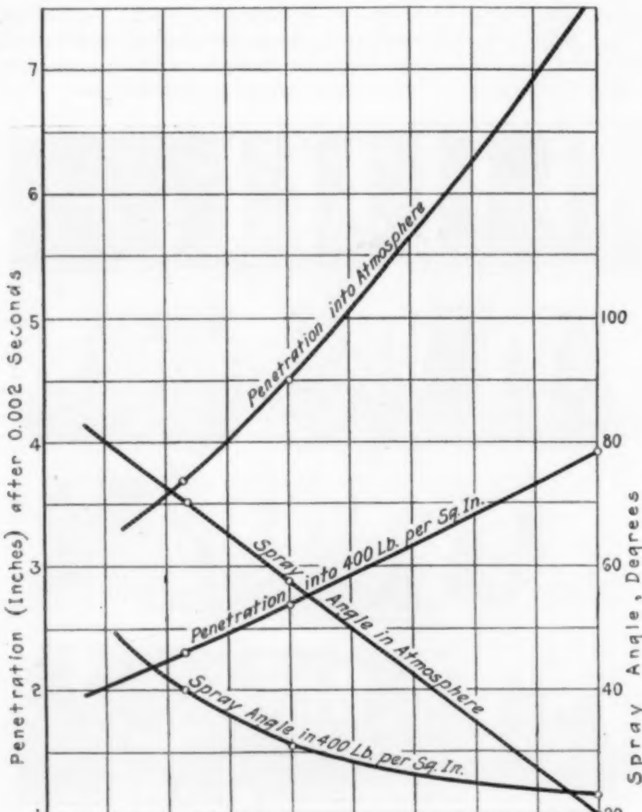

Fig. 4 Effect of Groove Helix Angle on Centrifugal Sprays

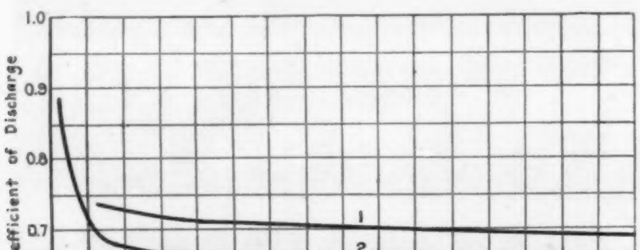

Fig. 5 Effect of Orifice Size on Coefficient of Discharge
(Orifice Size: Curve 1, 0.015 in. by 0.050 in.; Curve 2, 0.020 in. by 0.060 in.; Curve 3, 0.025 in. by 0.060 in.)

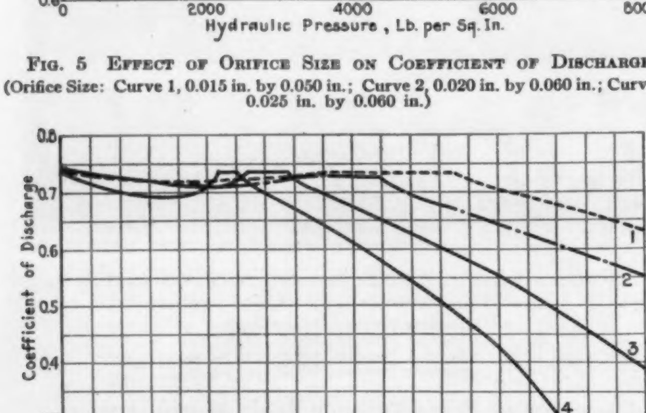

Fig. 6 Effect of Back Air Pressure on Coefficient of Discharge
(Diesel-engine fuel oil at 80 deg. fahr., discharged through a 0.020-in. orifice into air at various pressures. Hydraulic pressures: Curve 1, 2,045 lb. per sq. in.; Curve 2, 1,645 lb. per sq. in.; Curve 3, 1,255 lb. per sq. in.; Curve 4, 1,005 lb. per sq. in.)

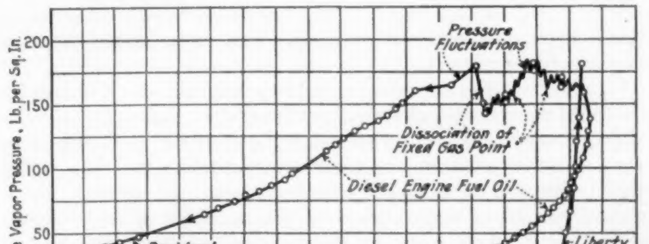

Fig. 7 Vapor Pressures of Diesel Fuel Oil and Lubricating Oil

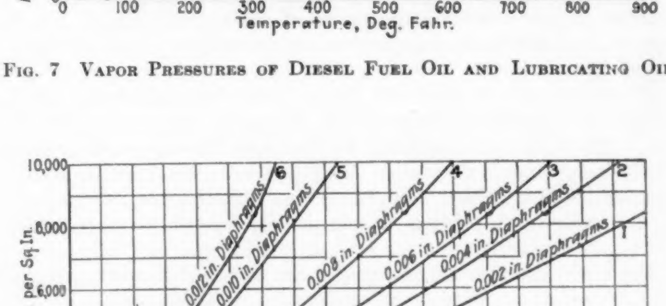

Fig. 8 Load Capacities of Multiple Diaphragms
(Pressure variations with change of multiple thickness taken at a deflection of 0.008 in. for all diaphragms.)

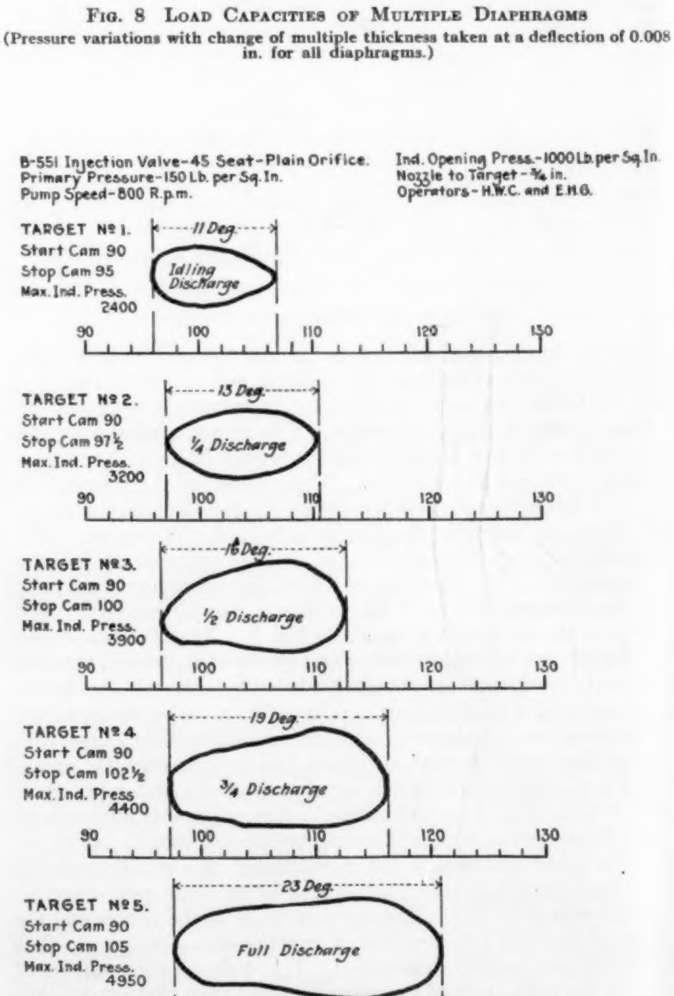

Fig. 9 Fuel-Spray Patterns, Showing Lag and Duration of Injection

ployed to meet the engine requirements. An investigation was therefore made of the coefficients of discharge of liquids through small round orifices. Flow of the liquids tested under high pressure was obtained with an intensifier consisting of a 5-in. piston driving a direct-connected $^3/_4$-in. hydraulic plunger. The large piston was operated by compressed air and the time required for the displacement of a definite volume by the hydraulic plunger was measured with an electrically operated stop watch. The coefficients were determined as the ratio of the actual to the theoretical rate of flow, where the theoretical flow was obtained by the usual simple formula for the discharge of liquids through orifices.

Values for the coefficients were determined for the more important conditions of engine service, such as discharge under pressures up to 8000 lb. per sq. in., at temperatures between 80 and 180 deg. fahr. and into air compressed to pressures up to 1000 lb. per sq. in. Fig. 5 shows the effect of orifice size on the coefficient for Diesel-engine fuel oil for hydraulic pressures up to 8000 lb. per sq. in. Fig. 6 shows the effect of discharging Diesel oil at various pressures through a 0.020-in. orifice into compressed air. The general results of this investigation show that the coefficient does not change materially for hydraulic pressures above 1000 lb. per sq. in. with either pressure or temperature, that it depends considerably upon the liquid, decreases with increase in orifice size, and remains practically constant in the case of discharge into compressed air until the compressed-air pressure equals approximately three-tenths of the hydraulic pressure, beyond which pressure ratio it decreases rapidly.

Vapor Pressure-Temperature Relations of Various Fuels

The vapor pressure-temperature relations of a number of fuels have been determined to obtain information relating to their critical points, thermal reactions, and relative rates of vaporization at high temperatures. A heavy gas-tight steel bomb fitted with valves, connecting tubes, and a pressure gage was used to hold the fuels under test. The bomb was heated by an electric furnace and the temperatures recorded by a thermocouple and a sensitive potentiometer. The liquids tested were water, ethyl and methyl alcohol, gasoline, benzol, kerosene, Diesel-engine fuel oil, lubricating oil, and mixtures of gasoline and ethyl alcohol and of gasoline and benzol. Pressures up to 5000 lb. per sq. in. and temperatures up to about 900 deg. fahr. were recorded. Fig. 7 shows the vapor pressures for Diesel-engine fuel oil and lubricating oil up to about 825 deg. fahr. Analyses of all the results obtained have not been completed. The outstanding features, however, are the stability of water and benzol, as shown by the fact that their heating and cooling curves are coincident, and the dissociation and thermal and catalytic reactions of the other fuels, as indicated by the character of their heating and cooling curves, the quantities of residual or fixed gases generated and removed from the bomb after complete cooling, and by the changed character of the fuels tested. The rapid increase in vapor pressure for the heavier fuels at about 800 to 850 deg. fahr. was very marked. These results indicate the minimum compressed-air temperatures required to force the rapid vaporization of fuel sprays in engine cylinders.

Steel Diaphragms for Injection Valves

The use of steel diaphragms to serve as the flexible member in injection valves, thus replacing the relatively heavy spring and stem, is especially attractive for high-speed-oil-engine operation. The facts that diaphragms have frequencies much higher than those of other forms of springs for the same masses and forces, that their inertias are small, and their accelerations are unrestricted by external friction, permit them to react to the high-speed intermittent hydraulic impulses from the pump. At the same time, diaphragms eliminate the necessity for the use of lapped valve stems and guides with their subsequent wear and leakage. An investigation was therefore made to determine the characteristics and load capacities of steel diaphragms of a size suitable for use in injection valves.

All diaphragms were firmly clamped at their edges in an injection valve designed for their use and loaded by hydraulic pressure. The deflections were measured with a dial test indicator. The diameters of the unsupported area and of the whole diaphragm were 0.4 in. and 0.5 in., respectively. The research determined the load-deflection, load-deformation, and hysteresis characteristics for single diaphragms having thicknesses of from 0.002 to 0.012 in., and for similar diaphragms tested in multiple having total thicknesses of from 0.012 to 0.180 in. The elastic-limit loads and deflections and rupture points of single diaphragms also were determined. The effect of orifice diameter upon the load-deflection characteristics of diaphragms having central orifices was determined.

Fig. 8 shows the load capacities for diaphragms of various thicknesses tested in multiple up to a total thickness of 0.180 in., or to 10,000 lb. per sq. in. hydraulic pressure. The results of this investigation indicate, and considerable subsequent engine service shows, that diaphragms are practicable for use in injection valves for high-speed oil engines.

Fuel-Injection Bench Tests

The performance testing, and calibration of fuel-injection pumps, injection valves, and other miscellaneous injection equipment is carried out on the bench. The apparatus most used for this work is arranged for attaching fuel pumps and valves and consists essentially of a motor-driven jackshaft with a flywheel, and a deflector

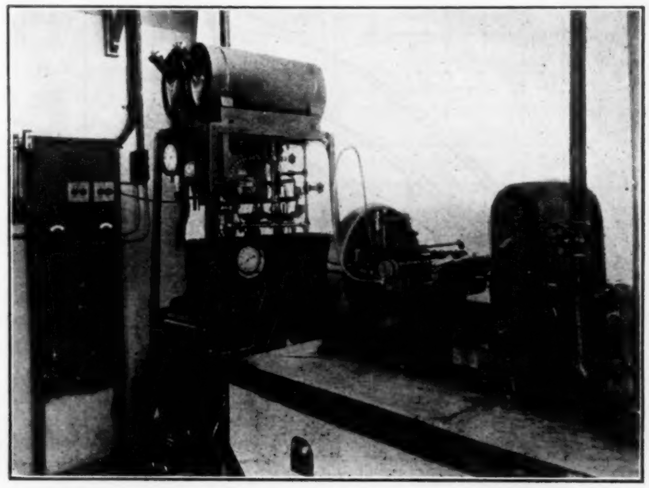

Fig. 10 Special Fuel-Injection Bench Testing Equipment

and clutch mechanism which permit the passage at will of one or more oil sprays to a target held on and rotated with the flywheel. By means of this apparatus the effects of engine speed, injection-valve design, and opening pressure, primary fuel pressure, injection-valve tube length, and closure and opening of the pump relief valve at various points in the pump cycle, on the lag of the spray behind the pump cycle have been determined. The duration of injection, the maximum injection pressures developed, and the fuel weight discharged per cycle for various pump settings also have been determined. This equipment is also fitted with a light-proof spray chamber and an oscilloscope, thus permitting the visual study of the start, development, and cut-off of oil sprays during running conditions. Fig. 10 is a photograph of the special fuel-injection bench testing equipment, showing an eccentric-driven high-pressure fuel pump and injection valve ready for test. Fig. 9 shows a series of spray patterns obtained with this apparatus. By means of such spray patterns and other records as given in Fig. 9, the characteristics of fuel-injection pumps, valves, and tubes are determined, the injection advance angles for oil sprays in engine testing calculated to within $^1/_2$ deg. of engine crank angle, and analyses of engine performance materially aided.

Engine Tests

The final tests of all fuel-injection equipment are made on single-cylinder test engines, where also the relative values of different types of cylinder-head construction and combustion-chamber shapes are determined. Two single-cylinder engines are used at present in oil-injection-engine research. One engine has a Liberty test-engine base and uses aircraft-engine parts, except for a special steel cylinder which permits the adaptation and study of various cylinder heads. The fuel-injection equipment consists of a tool-steel gear pump for the delivery of the fuel at moderate pressures to the injection pump,

volumetric fuel-measuring chambers for the determination of fuel consumption, a cam-operated fuel-injection pump and a spring-loaded injection valve producing highly atomized centrifugal sprays. The cylinder head now under test has a pear-shaped combustion chamber connected with the cylinder by a relatively small hole so placed as to produce high gas rotation in the bulb on the compression stroke and also in the engine cylinder on the power stroke. The size and shape of the hole between the bulb and cylinder are being progressively altered to determine engine performance for various kinds and degrees of turbulence. Preliminary tests with the

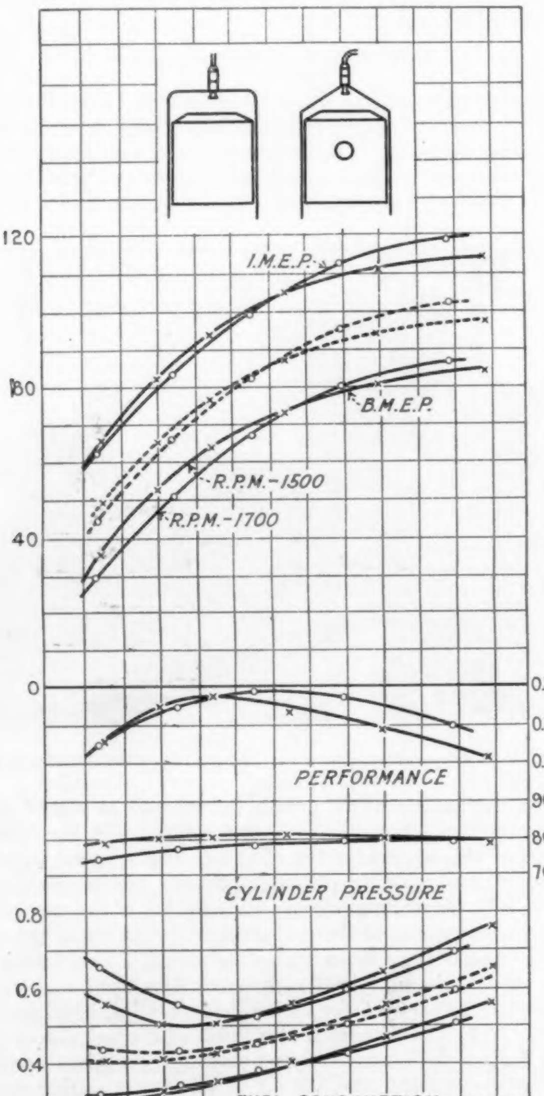

FIG. 11 ENGINE PERFORMANCE WITH UNIVERSAL TEST ENGINE

above cylinder head showed the mechanical efficiency of this engine to be particularly low, and that if this is corrected to a more normal value, namely, 80 per cent at 1600 r.p.m., the brake mean effective pressures and fuel consumptions for the whole speed range will be considerably improved. Thus, the brake mean effective pressures for a well-designed multi-cylinder engine with this type of combustion chamber at 1000, 1400, and 1800 r.p.m. will be 98, 92, and 85 lb. per sq. in., respectively. The corresponding fuel consumptions will be 0.54, 0.56, and 0.61 lb. per b.hp-hr. The practical constancy of the fuel consumptions per i.hp-hr. for both the $^2/_3$- and full-load tests are worthy of note. Considerable increases in power and decreases in fuel consumption have been obtained with this engine by recent alterations in the cylinder head.

The N.A.C.A. Universal test engine, also used in fuel-injection research, has provisions for varying the compression ratio, the timing and lift of the inlet and exhaust valves, and the timing of injection during engine operation. The test equipment consists chiefly of a heater for inlet-air temperature control, a surge chamber, and gasometer for air-consumption measurements and the usual torque, speed, pressure, and temperature-measuring apparatus and controls. The fuel-injection equipment consists of a tool-steel gear pump for pumping the fuel oil to the high-pressure eccentric-driven injection pump, automatic fuel scales for obtaining fuel consumptions directly, and a new type of injection valve. This engine is now being used to determine the effects of various compression ratios, chiefly on power, explosion pressures, and fuel consumption.

The performance of this engine for 1500 and 1750 r.p.m. and variable load is given in Fig. 11. Although the shape of the combustion chamber was not designed for and is not well adapted for high-speed-oil-injection-engine work and turbulence is of a very questionable nature, reasonably good results have been obtained, due to the special type of injection valve used. Thus at full load, which is defined in this paper as that quantity of fuel per cycle which provides 15 per cent excess air in the cylinder, the brake mean effective pressure for either speed is about 82 lb. per sq. in., and the fuel consumption about 0.63 lb. per b.hp-hr. If these values are corrected for mechanical efficiency they become, for a well-designed multi-cylinder engine, 94 and 98 lb. per sq. in. b.m.e.p., and 0.55 and 0.53 lb. per b.hp-hr. fuel consumption for 1500 and 1750 r.p.m., respectively. The better performance recorded at the higher speed is explained by small differences in the compression ratios and in the injection valve. The performance at lighter loads, namely, for aircraft cruising speeds, is considerably better. At half and three-quarter loads, the b.m.e.p. will be about 63 lb. per sq. in. and 85 lb. per sq. in. and the fuel consumptions per b.hp-hr. will be about 0.42 and 0.46 lb., respectively. It is expected that the performance for all loads and speeds will be considerably improved by new cylinder heads now being designed and a more advanced design of the special-type injection valve.

The Fear of Overproduction

IN conclusion let me say, that it seems to me that the world is obsessed with the fear of overproduction, and that there isn't business enough to go around. One of the grievances often charged against the labor organizations is that they sometimes restrict the output, acting upon the theory that there is only a limited amount of work to be done, and that the farther they can make it go and the more they can make it pay in wages, the better. It is a mistaken idea, which raises the cost of living for the workmen themselves; but it is not at all different from the ideas that often govern the policies of statesmen and business men. The truth is that there is no limit to the amount of work to be done in the world, or to the amount of business to be had, or to the amount of wealth that may be created from the resources of nature. The purchasing power of every country is in its own powers of production, and the greatest prosperity for every country is to be had in connection with the prosperity of all other countries.

There can be no such thing as general overproduction so long as human wants are unsatisfied. What looks like it, is simply unbalanced production. There is not a family in a four-room apartment in this city that would not like to have a six-room apartment, or one with six rooms that would not like to have more, and all the furnishings to go with it. There isn't a family without an automobile that wouldn't like to have one, and most of the families having one would like to have another.

The great problem of the world is to so organize and integrate and coördinate the resources and industries of the world as to secure the greatest possible production and distribution of all the things that minister to the comfort and welfare of the population. That is the great appeal to the enlightened and constructive people of the world. (Geo. E. Roberts, vice-president, National City Bank of New York, in an address on The World Economic Organization before the Society of Engineers of Western Pennsylvania.)

The Potentiometric Determination of Hydrogen-Ion Concentrations as Applied to Boiler Waters

By WILLARD N. GREER[1] and HENRY C. PARKER,[1] PHILADELPHIA, PA.

In this paper the author discusses methods of controlling boiler water or boiler feedwater, and compares the various methods of hardness determination. It is shown that when hydrolyzable salts are present a titration with indicators is only an approximate method of determining the acidity or the alkalinity of a solution. It appears that a measurement of ion concentration is necessary before any definite relation can be established between the concentration of boiler chemicals and caustic embrittlement, foaming, corrosion, formation of scale, and other boiler phenomena.

In a discussion of the soap test for determining hardness, it is shown that this method is, at best, only an approximation. The method is especially in error in water containing appreciable amounts of magnesium, tests on samples containing known amounts showing results 30 to 35 per cent low. The results obtained might be termed "apparent hardness."

There is a more or less definite relation between the alkalinity and pH of natural waters at the lower alkalinities.

The electrometric method of hydrogen-ion concentration is discussed and a comparison with other methods made. The use of the hydrogen, quinhydrone, and tungsten electrodes is described, and it is shown that the latter two can be used in a flowing solution to give a continuous record of pH.

The dissociation of water into its constituents, hydrogen ions H^+, characteristic of acids, and hydroxyl ions OH^-, characteristic of bases, has an important bearing on the properties of salts in solution. According to the kinetic theory, the process is such that, at equilibrium, the rate of formation of the ions from the water molecules is equal to the rate of recombination of the ions. Expressing the equilibrium mathematically,

$$\frac{[H^+] \times [OH^-]}{[HOH]} = k$$

where the brackets [ ] indicate concentrations. Since water is only slightly ionized, the concentration of the undissociated water [HOH] may be considered a constant at a given temperature, and combined with k. The above equation then becomes:

$$[H^+] \times [OH^-] = K \ldots\ldots\ldots\ldots [1]$$

The constant K has been determined, by a variety of methods, to be 10^{-14} at 22 deg. cent. The value of K increases considerably at higher temperatures.

The introduction of an acid into water increases the hydrogen-ion concentration, and the introduction of a base increases the hydroxyl-ion concentration. In either case, assuming the law of mass action to hold, the equilibrium condition is such that, under the same temperature conditions, Equation [1] applies. These considerations show that, whatever the concentration of hydroxyl ions, there are always hydrogen ions present, and we may speak of the hydrogen-ion concentration of a solution which is really basic.

Hydrolysis of Salts

The temperature and the constituents of a salt, MeX, determine the degree of hydrolysis in solution. Both anion and cation can react with the ions of water:

$$Me^+ + HOH \rightleftarrows MeOH + H^+ \ldots\ldots\ldots\ldots [2]$$

$$X^- + HOH \rightleftarrows HX + OH^- \ldots\ldots\ldots\ldots [3]$$

The salts of strong acids and strong bases are largely dissociated. Since such salts are not hydrolyzed to any appreciable extent, the hydrogen-ion concentration of their solutions is about 10^{-7} at ordinary temperatures. Acids and bases affect the hydrogen-ion concentration of such solutions in the same way as that of pure water.

A salt of a weak base and a strong acid will react according to Equation [2] and the solution will have an acid reaction. A salt of a strong base and a weak acid will react according to Equation [3] and the solution will have an alkaline reaction. In titrating a solution of magnesium chloride, $MgCl_2$, it is evident that sufficient alkali would have to be added to neutralize the HCl formed by the hydrolysis. A similar effect is caused when making an alkalinity determination of a carbonate, such a solution requiring additional acid to neutralize the OH^- formed by the hydrolysis.

It is evident that the true neutral point of a solution occurs when $[H^+]$ and $[^-OH]$ are equal, and have a value of 10^{-7} at ordinary temperatures (Equation [1]). The end point with phenolphthalein, however, occurs when the hydrogen-ion concentration is approximately 10^{-8}, and that with methyl orange when the hydrogen-ion concentration is approximately 10^{-5}. This shows that when hydrolyzable salts are present a titration with indicators is only an approximate method of determining the acidity or the alkalinity of a solution. A titration may be said to give a measure of the *available* acidity, while hydrogen-ion measurements give the true or *actual* acidity of a solution. It is the latter factor which determines the *reactivity* of a given solution. Hence the measurement of *ion* concentration will undoubtedly be necessary before any definite relation can be established between the concentration of boiler chemicals and caustic embrittlement, foaming, corrosion, formation of scale, and other boiler phenomena.

Instead of expressing the hydrogen-ion concentration as a negative exponent, Sorensen suggested the use of the term pH, the pH value being the logarithm of the reciprocal of the hydrogen-ion concentration, $pH = \frac{1}{\log[H^+]}$. A neutral solution, then, has a pH of 7, and the end points of phenolphthalein and methyl orange occur approximately at a pH of 8 and 5, respectively. A solution normal with respect to hydrogen ions has a pH of 0, while a solution normal with respect to hydroxyl ions has a pH of 14.

At the higher temperatures and concentrations the measurements of the ion concentrations become of increasing importance, due to the fact that the ionization of electrolytes decreases considerably at these temperatures.[2] This is especially true of the more complex salts, since the ionization of such salts falls off more rapidly than does that of the binary salts. Measuring the hydrogen-ion concentration of boiler water at ordinary temperatures does not give a measure of this value at boiler temperatures, but it is usually a much more valuable measurement than the "alkalinity" at ordinary temperatures. (Of course an alkalinity determination at ordinary temperatures does not give a true measure of the alkalinity at boiler temperatures.) The latter does not take into account the presence of salts which may hydrolyze at the higher temperatures and thereby supply sufficient acid for corrosion. Hydrogen-ion measurements, on the other hand, do make allowance for these salts, due to their so-called "buffer" action. By "buffer" action is meant the resistance exhibited by a solution to change in pH upon the addition of alkali or acid.

A simple experiment is cited to illustrate the relation between alkalinity and pH of a solution containing a hydrolyzable salt. If just sufficient sodium hydroxide is added to distilled water so that on boiling the solution will remain pink to phenolphthalein, and then a solution of magnesium sulphate, for instance, is treated with sodium hydroxide to give the same alkalinity, the color of the latter will disappear on boiling. If, however, the magnesium sulphate solution is treated with sufficient sodium hydroxide to bring it to the same pH as the sodium-hydroxide solution, the

[1] Research Department, Leeds & Northrup Co.

Presented at the Buffalo, N. Y. Meeting, June 9, 1926, of the American Water Works Association, as part of the activity of the Joint Research Committee on Boiler-Feedwater Studies.

[2] Kraus, The Properties of Electrically Conducting Systems, p. 151. The Chemical Catalogue Co., New York, N. Y.

former will give a pink color with phenolphthalein on boiling. The results of such an experiment are tabulated below.

Distilled Water with NaOH

Alkalinity = 0.9 cc. H_2SO_4, pH = 9.65
(Pink to phenolphthalein on boiling)

$MgSO_4$ Solution

Added NaOH to give alkalinity = 0.9 cc. H_2SO_4
(Color disappeared on boiling)
Added NaOH to give pH = 9.65
(Color remained on boiling)

Sample of Boiler Water

Added H_2SO_4 to give pH = 9.65
(Color remained on boiling)
Added H_2SO_4 to give alkalinity = 0.9 cc. H_2SO_4
(Color disappeared on boiling)

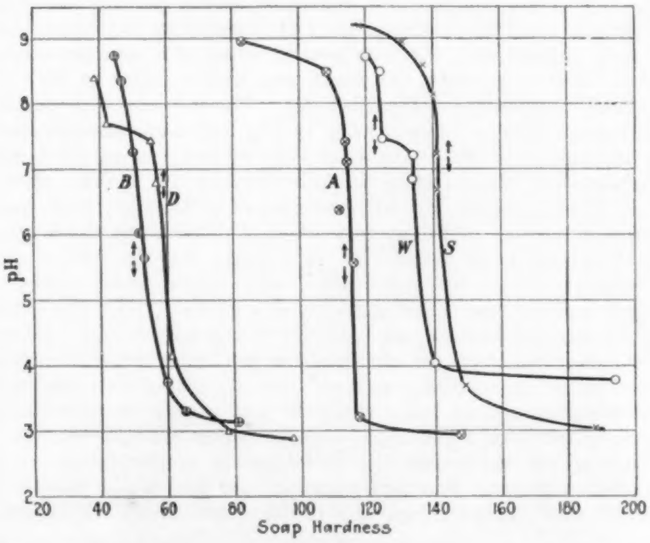

FIG. 1 RESULTS OBTAINED ON TREATING SOLUTIONS OF CALCIUM AND MAGNESIUM CHLORIDES AND SAMPLES OF WATER FROM THREE DIFFERENT RIVERS WITH SODIUM CARBONATE AND HYDROCHLORIC ACID, RESPECTIVELY

This experiment shows that a boiler freshly filled with condensate requires only a small fraction of the alkalinity which is required after the normal accumulation of salts. Control of the boiler water to a given pH would accomplish this. Hence, in cases where the pH of the boiler water is normally kept at a pH of 10.5 or below, it is probable that this type of control would be more satisfactory than alkalinity control. Above a pH of 10.5 the hydrogen-ion measurements would probably be found too insensitive.

The large "buffer" action of a small quantity of salts in water is further shown by a table given by Wilson,[3] who found that, in order to raise Cambridge tap water to a pH of 10 it was necessary to add 40 p.p.m. of sodium hydroxide, while the same requirement for distilled water was only 13 p.p.m. Thus, if the pH of this water, considered as boiler feedwater, had been kept constant by hydrogen-ion control, there would have been added 27 p.p.m. of caustic to allow for the salt content of the tap water. On the other hand, if the control had been by an "alkalinity" determination, no such allowance would have been made, and the salts would have gone into the boiler with no alkali to compensate for the acid liberated on hydrolysis at high temperatures.

It is not claimed that the excess caustic that would be added by hydrogen-ion control would be just sufficient to neutralize the acid liberated at boiler temperatures, but this allowance would be approximately correct for the following reason: It is well known that the salts which hydrolyze slightly at normal temperatures are the ones which exert the greatest "buffer" action. Thus the content of sodium chloride would have very little effect on the amount of caustic required to bring the boiler feedwater to a given pH value. On the other hand, a salt like magnesium chloride would have a much greater "buffer" action, and this is the type of salt which would be expected to liberate acid at the higher temperatures.

HARDNESS, ALKALINITY AND pH

The method of determining hardness by the soap test was first proposed by Clark.[4] This method, at best, is only an approximation, and has been criticized by various writers.[5] Especially is this method in error in waters containing appreciable amounts of magnesium. A few samples of water containing known amounts of calcium and magnesium chlorides in the ratio of two to one were tested for hardness by the soap method, and it was found that the results were from 30 to 35 per cent low. The results obtained might be termed the "apparent hardness."

The results obtained on treating solutions of calcium and magnesium chlorides, and samples of water from three different rivers, with sodium carbonate and hydrochloric acid, respectively, are shown in Fig. 1, where the apparent hardness is plotted as abscissas and the pH as ordinates. Curve *S* was plotted from data obtained on a sample of water from the Schuylkill River, curve *W* from a sample of the Wissahickon Creek, curve *D* from a sample of the Delaware River, curve *A* from a solution containing 0.475 gram of $CaCl_2$ and 0.235 gram of $MgCl_2$ per gallon of distilled water, and curve *B* from a similar solution containing 0.235 gram of $CaCl_2$ and 0.115 gram of $MgCl_2$ per gallon. Air was previously bubbled through these solutions for a few minutes, to produce as nearly as possible the condition of natural water. The initial pH and alkalinity of each sample is indicated by the point between the arrows, addition of sodium carbonate resulting in an increased pH, and addition of HCl resulting in a decreased pH. It is evident from these curves that the apparent hardness is practically independent of the pH between pH 4 and pH 7.5. It might be said that all waters are hard below pH 3.

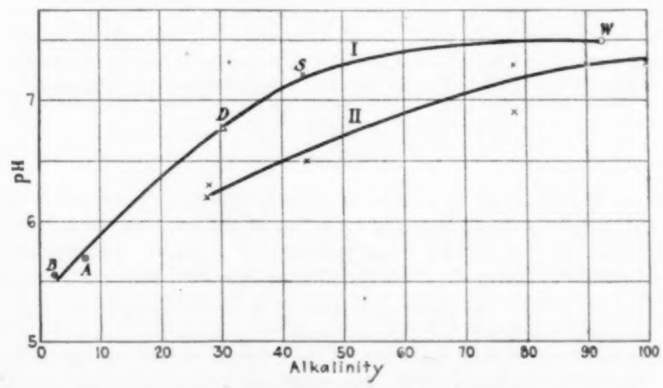

FIG. 2 RELATION BETWEEN pH VALUE AND ALKALINITY OF NATURAL WATERS

There is a more or less general relation between the pH and the alkalinity of natural waters. This is indicated by Fig. 2, where the pH is plotted as ordinate and the alkalinity as abscissa. The points *W*, *S*, and *D*, curve I, represent these values as determined from samples of the Wissahickon Creek and Schuylkill and Delaware Rivers, respectively. Points *A* and *B* were determined from solutions containing calcium and magnesium chlorides in distilled water, the composition of *A* being 0.475 gram $CaCl_2$ and 0.22 gram $MgCl_2$ per gallon, and that of *B*, 0.235 gram $CaCl_2$ and 0.115 gram $MgCl_2$ per gallon. Curve II was plotted from data by Greenfield and Baker[6] obtained on three different rivers in the Middle West.

ELECTROMETRIC DETERMINATION OF H-ION CONCENTRATION

The electrometric method is the fundamental method of determining hydrogen-ion concentrations. Other methods are referred to the electrometric method as a standard. Colorimetric methods give approximate values and may be used where only rough mea-

[3] *Jour. Ind. & Eng. Chem.*, vol. 15 (1923), p. 128.

[4] *Chemical Gazette*, vol. 5 (1847), p. 100.

[5] Hehner, *Analyst*, vol. 8 (1883), p. 77. Pfeifer, *Zeit. angen. Chem.* (1902), p. 193. Proctor, *Jour. Soc. Chem. Ind.*, vol. 23 (1904), p. 8.

[6] *Jour. Ind. & Eng. Chem.*, vol. 12 (1920), p. 990.

surements are desired. Of course, colorimetric determinations cannot be used where a continuous record of H-ion concentration is desired, but may be used as a rough check on electrometric determinations. The electrometric method of measuring H-ion concentration consists in measuring the voltage developed when suitable electrodes are immersed in the solution. It is beyond the scope of this paper to discuss in detail the derivation of the equations relating to pH and the potential difference between electrodes.[7] It will be sufficient to give a few fundamental relations.

The fundamental reference electrode is the hydrogen electrode. A noble metal, platinum generally being used, coated with platinum black may be made to serve as a hydrogen electrode. When it is saturated with hydrogen and immersed in a solution containing hydrogen ions, there is exhibited a difference of electrical potential between solution and electrode which is dependent upon the concentration of hydrogen ions. We have no means of measuring such a single potential, but if we have two such electrodes in separate containers and connected by means of a "salt bridge" we can measure the total e.m.f. We can show how this e.m.f. varies with the concentration of hydrogen ions from a derived equation.

$$\text{E.m.f.} = 0.000{,}198{,}37\ T \log \frac{C}{C'}$$

where T is the absolute temperature, and C and C' are the hydrogen-ion concentrations. If measurements are carried out at 25 deg. cent. the equation becomes: $\text{E.m.f.} = 0.0591 \log \dfrac{C}{C'}$

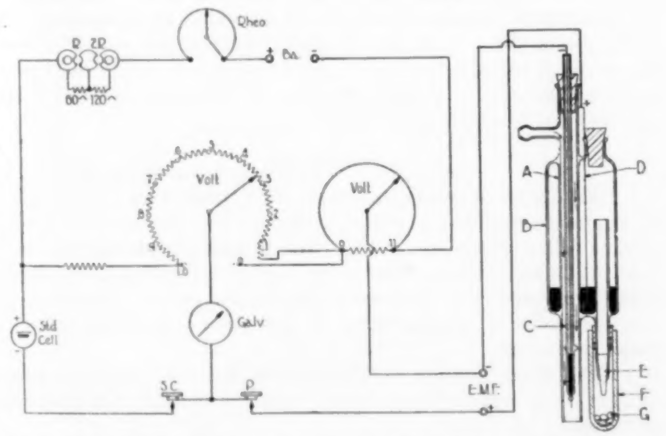

FIG. 3 COMBINED TYPE OF CALOMEL AND HYDROGEN ELECTRODES AND DIAGRAM OF POTENTIOMETER CIRCUIT

Instead of using two hydrogen electrodes it is more convenient to replace the standard hydrogen electrode with a calomel electrode. This is an electrode of mercury covered with calomel (Hg_2Cl_2) in the presence of a definite concentration of potassium chloride. A saturated solution of potassium chloride is generally used in industrial measurements, since there is less tendency for diffusion to change the concentration, its conductivity is high, and it shows no change in electrode potential between 5 and 60 deg. cent., except that which can be corrected by the temperature coefficient. At 25 deg. cent. the mercury of the calomel electrode is 0.246 volt more positive than the platinum of the normal hydrogen electrode. The voltage of the calomel electrode does not vary with changes in the hydrogen-ion concentration of the solution, as does the hydrogen electrode. The equation becomes:

$$\frac{\text{Observed e.m.f.} - 0.246}{0.0591} = \text{pH} \ldots\ldots\ldots\ldots\ldots [4]$$

As a means of measuring the e.m.f. between two such electrodes, a potentiometer is used. The outlines of a combined type of calomel electrode and hydrogen electrode[8] and a diagram of a potentiometer circuit are shown in Fig. 3. Electrical connection to the calomel electrode is made through D, and to the hydrogen electrode through C. The hydrogen is bubbled in through the tube A. A porous cup F contains a saturated solution of KCl above a few crystals of KCl, G, and forms a salt bridge to the calomel electrode, liquid connection being made through the ground-glass plug E. To measure the voltage of the electrodes it is only necessary to immerse the combined cell in the solution to a depth sufficient to cover the platinum electrode, bubble hydrogen through the solution around the electrode, and read off the voltage with

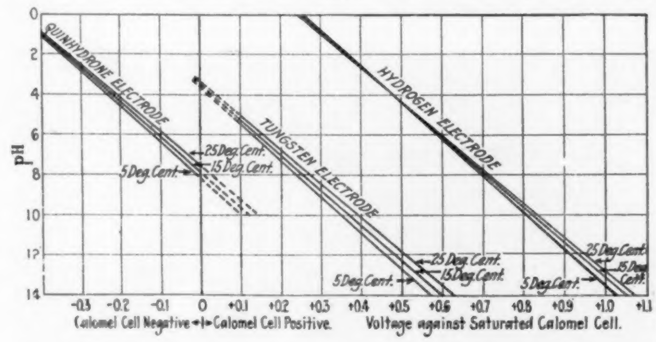

FIG. 4 CHART FOR CONVERTING VOLTAGE READING INTO pH VALUE

the potentiometer. The voltage reading may be converted to pH units by means of Equation [4], by a hydrogen-ion calculator, or read off directly from a pH-voltage chart, Fig. 4. Such a cell is used for intermittent measurements. The potentiometer can be made to read in volts, or directly in pH units.

ELECTRODES

The hydrogen electrode is the only electrode that will cover

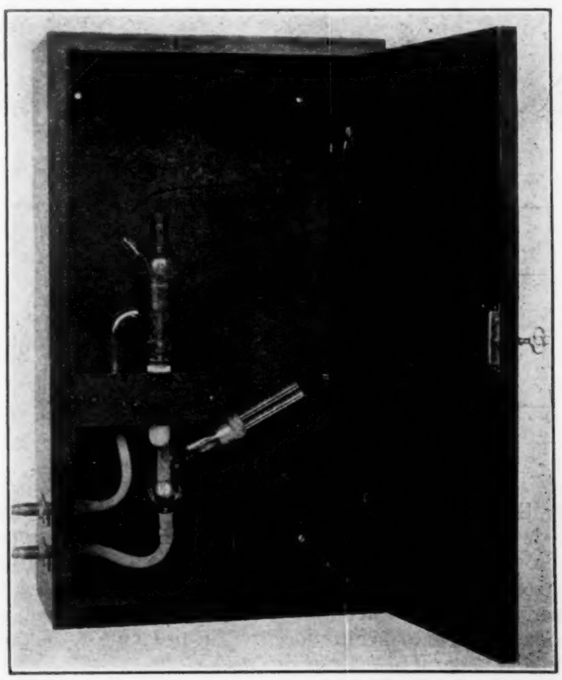

FIG. 5 FLOW CHANNEL CARRYING SATURATED CALOMEL CELL AND TUNGSTEN ELECTRODE

the entire pH range but, unfortunately, it is not suitable for use in a flowing solution without some method of presaturating the solution with hydrogen. There are several substances which have been found to "poison" this electrode, such as oxidizing substances, some organic compounds, and ions of metals more noble than hydrogen. There are, however, a great many industrial processes in which the hydrogen electrode is applied, among which might be mentioned tanning, baking, etc.

The tungsten electrode[9] is apparently the most free from poison-

[7] For a complete discussion, see Clark, The Determination of Hydrogen Ions, Williams and Wilkins, Baltimore, Md.

[8] Parker and Dannerth, *Jour. Ind. & Eng. Chem.*, vol. 17 (1925), p. 640.

[9] Baylis, *Jour. Ind. & Eng. Chem.*, 15 (1923), p. 852. Parker, *Jour. Ind. & Eng. Chem.*, 17 (1925), p. 737. Parker and Baylis, *Jour. Am. Water Works Assoc.*, vol. 15 (1926), p. 22.

ing effects. It is best used in a flowing solution, and is adapted for intermittent measurements only by following a definite procedure. Its accuracy, however, is not greater than ± 0.1 pH, and it is not satisfactory for use in solutions more acid than pH 5. A flow channel carrying a saturated calomel cell and tungsten electrode is shown in Fig. 5. The pH-voltage relations of the tungsten electrode are shown in Fig. 4.

For intermittent measurements the procedure used is to keep the electrode immersed in a stable buffer solution of approximately the same pH as that of the test solutions, removing the electrode only during the time of use. When used in a flowing solution an electrode is introduced into the cell (or is placed in a buffer solution) twenty-four hours before being connected to the recorder. Experience determines how often, in general, a new electrode will have to be introduced. The usual life of the tungsten electrode in boiler feedwater is two weeks.

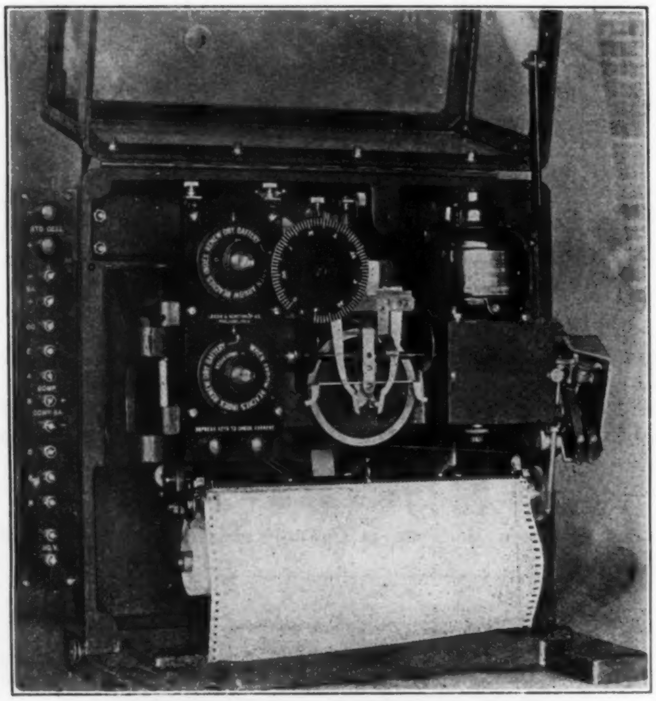

FIG. 6 RECORDING POTENTIOMETER

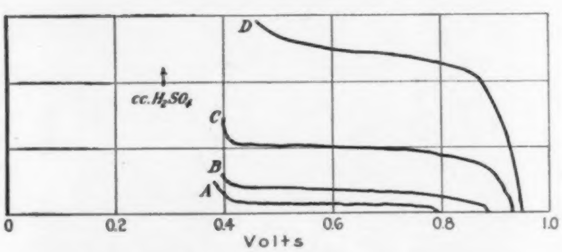

FIG. 7 TITRATION CURVES OF BOILER WATERS

The quinhydrone electrode[10] is not so subject to poisons as is the hydrogen electrode, but does not give a completely stable reading in solutions more alkaline than pH = 8. Measurements may be made in more alkaline solutions, provided the measurements are made quickly and the first reading is taken as being correct. Flowing solutions of boiler feedwater have been measured as high as pH 8.6. A small salt error which is present does not prohibit its use, since the relative value will remain the same, if a series of measurements is made. The combined-type cell, Fig. 3, may be used for a quinhydrone electrode[11] (a gold electrode is recommended in place of platinum) if a few cc. of saturated quinhydrone solution, or a few crystals of quinhydrone, are added to the test solution. The quinhydrone electrode can also be applied for measuring the pH of a flowing solution. The accuracy, simplicity, ease of manipulation, and freedom from poisoning make this electrode ideal for a large number of industrial applications.

RECORDING pH

In processes where a continuous record of the pH is desired, use is made of a recording potentiometer, Fig. 6. The titration curves of samples of boiler feedwater with H_2SO_4, using such a recorder, are shown in Fig. 7. Curve A was obtained by adding H_2SO_4 at a constant rate to a sample from a boiler whose feedwater had no pretreatment, Curves B and C with boiler feedwaters previously treated with caustic soda, and Curve D with lime-and-soda-treated feedwater. The original pH values of these samples were $A = 9.65$, $B = 10.8$, $C = 11.6$, and $D = 11.9$.

The use of a recorder-controller potentiometer will be discussed in a subsequent paper on the automatic control of hydrogen-ion concentration of boiler feedwater.

If the pH of boiler water is maintained at a value of 9 to 10, pH measurements will give an indication of an excess or deficiency of caustic. At higher pH values, however, the change in pH with increased causticity is too small to be of real value, as is indicated by Curves C and D, where the difference in pH is only 0.3, whereas the difference in alkalinity is considerable.

Perhaps the most important use of pH measurements is in determining the proper treatment when first starting up a boiler. In such cases pH measurements give a much better indication of the amount of chemical that should be added to compensate for hydrolyzable salts, than do alkalinity determinations. Measurements of pH will also indicate the building up of salts in the boiler, and may be used as a true indication of chemicals required if the pH does not exceed a value of 10.5.

SUMMARY

1 Alkalinity measurements have long been used as a method of approximating H-ion concentrations. The presence of hydrolyzable salts introduces an error, the magnitude of which is such that the determinations are of value only for indicating the available acidity or causticity. Consequently, hydrogen-ion measurements are frequently of greater value in the control of boiler water or boiler feedwater.

2 The determination of hardness by the soap method gives, at best, only approximate values, which are nearly independent of the pH.

3 There is a more or less definite relation between the alkalinity and pH of *natural* waters at the lower alkalinities.

4 The use of the hydrogen, quinhydrone, and tungsten electrodes has been described. The latter two can be used in a flowing solution to give a continuous record of pH.

Working on the hypothesis that water to be filtered must be under slightly more pressure at the surface of the filter medium than where the air is introduced into the reaction tanks, the General Petroleum Co. of Los Angeles, Cal., has shown that the head must be at least 13 ft. Their experiments showed that at all heads above that point perfect filming took place on the sand surface, and the clarity of the distillate was excellent. The conclusion is that under 12 ft. or less head there is a definite volcanic action in the sand bed, the air in the water escaping upward and forming craters in the sand surface, these allowing the precipitate to gradually work through the bed.

A filter operating under a head of 13 ft. or more was built by the company, with provisions made for removing a portion of the sand surface along with the deposits as required. Although it was expected that a small portion would be removed each day, it was discovered that the precipitate acted as a filtering medium and, after several months operation, at rates of flow varying from 800,000 to 1,500,000 gal. per 24 hr., the sand cut was not over 1/2 in. The filtrate was of excellent clarity, and boilers formerly requiring cleaning every 60 to 70 days showed no appreciable scale formation after 60 days of operation. *Power Plant Engineering*, Oct. 1, 1926, pp. 1050 and 1051.

[10] For bibliographies on the quinhydrone electrode see Billman, Trans. Faraday Soc., vol. 19 (1924), p. 676, or Kohltoff and Furman, Potentiometric Titrations, p. 220, John Wiley & Sons, N. Y.

[11] Parker and Greer, Preprint No. 2, April, 1926, Am. Electrochemical Society.

Effect of Temperature on Liberation of Hydrogen Gas by Corrosion of Iron and Zinc

By JOHN R. BAYLIS,[1] BALTIMORE, MD.

THIS is a progress report on one phase of the study of the effect of temperature on corrosion, and is not a complete treatise of the subject. The work has just begun and it is entirely too early to form conclusions with the limited number of tests which have been completed.

Experimental work on the effect of temperature has been confined largely to corrosion in the absence of oxygen. In this case the liberation of hydrogen gas is used as a measure of the corrosion rate. Tests have been made with the temperature ranging only from 4 to 100 deg. cent. Most of the tests on iron have been on freshly cut and very finely cut lathe turnings so as to give a very large surface area. For zinc, certain portions of the screened metal, usually 20-mesh, were used.

Apparatus

A weighed amount of the sample is placed in a pyrex flask as shown in Fig. 1. The tube leading from the flask is bent into an M-shape, and is graduated the entire length as it is desirable to

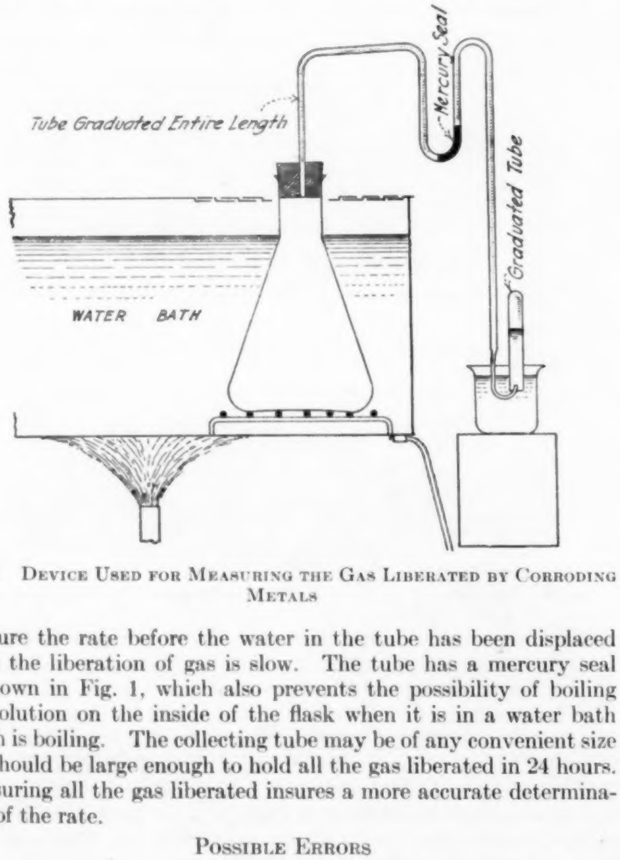

Fig. 1 Device Used for Measuring the Gas Liberated by Corroding Metals

measure the rate before the water in the tube has been displaced when the liberation of gas is slow. The tube has a mercury seal as shown in Fig. 1, which also prevents the possibility of boiling the solution on the inside of the flask when it is in a water bath which is boiling. The collecting tube may be of any convenient size but should be large enough to hold all the gas liberated in 24 hours. Measuring all the gas liberated insures a more accurate determination of the rate.

Possible Errors

There are two possible errors affecting the initial rate of corrosion which may be due to the apparatus used. One is the amount of hydrogen gas which goes into solution before bubbles start to form, and the other is the amount of water actually displaced by the bubbles before they rise to the top of the flask. This, however, affects only the first results and the error is not great at 100 deg. cent. Measurement of the rate is not started until after gas bubbles begin to rise to the top of the flask, and the time before reliable results may be obtained will depend on conditions. If the corrosion rate is fast, one or two hours will be sufficient, but if quite slow it may require a day or more. In most of the tests so far conducted on iron, one day has been allowed when the temperature is near the boiling point, and frequently a longer period for lower temperatures. The gas is liberated from corroding zinc much more rapidly than for iron, and shorter periods are usually sufficient for a constant flow of gas to be attained.

Corrosion of Iron in the Absence of Oxygen

In the absence of oxygen, iron corrodes in proportion to the amount of hydrogen gas liberated, and where it is known that no oxygen is present, either as dissolved oxygen or in higher oxides

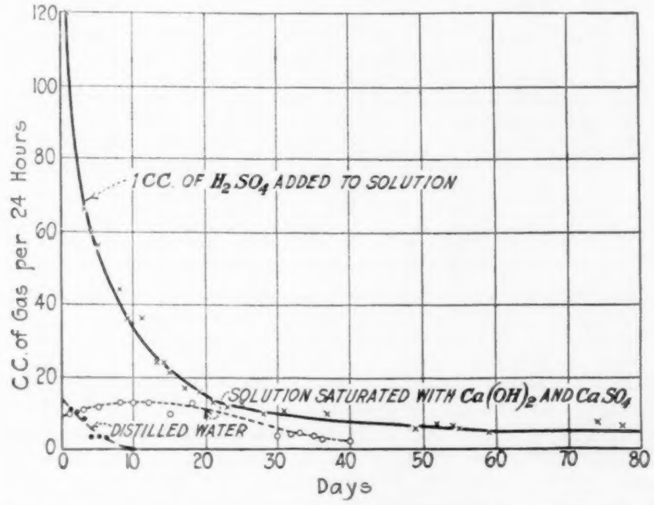

Fig. 2 Hydrogen Gas Liberated by Corroding Iron (100 Grams of Lathe Turnings) at 100 Deg. Cent.

which may be reduced, the measurement of the hydrogen gas serves as an accurate measure of the corrosion rate. Most students of corrosion concede that some hydrogen gas is liberated by corroding iron, even when dissolved oxygen is present in the surrounding solution. In other words, the liberation of hydrogen gas seems to be a process, partially, if not entirely, independent of the corrosion taking place by the oxidation of nascent hydrogen. This being the case, corrosion is not entirely stopped by having the water free from dissolved oxygen, but the rate is usually very slow in proportion to what it would be if dissolved oxygen were present. Recent literature has given most attention to corrosion in natural waters by the oxidation of the hydrogen. It is well that this has been given the greatest prominence, but a warning should be given that the solution of all corrosion problems is not dependent upon the elimination of dissolved oxygen.

The curves in Fig. 2 show the hydrogen gas liberated by corroding iron in the absence of dissolved oxygen for quite variable characters of water. If pure iron is submerged in pure water free from negative ions other than the $(OH)^-$ ions, it usually does not corrode to the extent of liberating gas bubbles when the temperature is below about 20 deg. cent., even after standing for several months. When the temperature is near 100 deg. cent., bubbles are given off at first. Iron, however, rapidly becomes passive and within a few weeks the liberation of gas usually stops. This is shown by the curve for distilled water in Fig. 2. If a saturated solution of calcium hydroxide and calcium sulphate is used, very much more gas will be liberated as shown. The shape of this curve may be due to the fact that the flask was held for 14 days at 22 deg. cent. before putting into the water bath. No gas bubbles were liberated at the lower temperature. This should be interesting from the fact that corrosion is not stopped in the presence of a saturated solution of limewater if certain negative ions are present.

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Abridged from a paper presented at the Buffalo, N. Y., meeting, June 9, 1926, of the American Water Works Association.

The curve for the solution containing 1 cc. of sulphuric acid shows another interesting phenomenon in the corrosion of iron. The chemical reaction between the acid and the iron should be complete within less than one day at a temperature of 100 deg. cent., and if a constant pH for the solution is any indication, the reaction is complete within much less than 24 hours. This sample has continued to give off hydrogen gas for 64 days, though the rate is decreasing gradually. The total gas given off after the first 24 hours is approximately 20 per cent of that given off the first day when the chemical reaction was taking place.

About 50 grams of lathe turnings from a steel pipe have been placed in the bottom of a glass tube $1^1/_2$ in. in inside diameter and

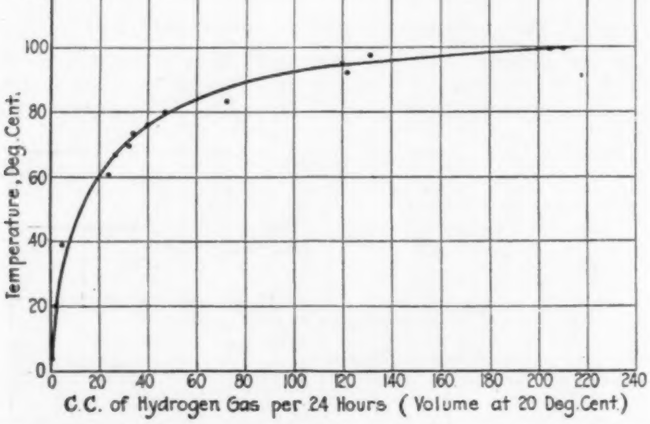

FIG. 3 THE EFFECT OF TEMPERATURE ON THE INITIAL CORROSION RATE OF ZINC IN THE ABSENCE OF OXYGEN
(50 grams of 20-mesh chemically pure zinc.)

10 in. long, and this tube has been kept full of Baltimore City water to which has been added enough calcium sulphate to make it approximately half saturated. It has been left open so that oxygen and other gases present in the air may be absorbed. Evaporation losses are replaced with the tap water. The tube has been kept in the laboratory where the temperature averages about 22 deg. cent. At the time of this writing it has stood nine months and has continued to give off hydrogen gas bubbles all the time. The continuous process probably is due to CO_2 being absorbed from the air; however, the significant point is that all indications point to the fact that the prevailing reaction is the liberation of hydrogen gas and not the oxidation of nascent hydrogen.

It is quite probable that the prevailing reaction in the corrosion of many boilers is the liberation of hydrogen gas. It is well known that the corrosion rate increases as the temperature increases when below 100 deg. cent. Does it continue to increase as the temperature is increased above 100 deg. cent., or does the pressure have a retarding effect? The writer has no information on the effect of pressure upon corrosion rates, but we do not ordinarily think of a pipe line which is under high pressure as corroding at a slower rate than when the pressure is low. If corrosion rates do increase as the temperature increases, it is difficult to predict what is happening in some of the high-pressure boilers.

CORROSION OF ZINC

Should there be any doubt about the corrosion of iron being electrochemical, there is none about zinc. It corrodes quite readily in water free from dissolved oxygen by the liberation of hydrogen gas, except when the temperature is near the freezing point of water. Dissolved oxygen may hasten the corrosion rate by oxidizing nascent hydrogen, but it certainly is not an essential. The curve in Fig. 3, which was prepared for use in a recent article,[2] shows the remarkable influence of temperature on the initial corrosion rate of zinc. Protection of the metal depends primarily on the formation of an impervious surface coating.

The solubility of zinc hydroxide or other zinc salts in the presence of the metal, depends upon the pH and to a slight extent upon the concentration of the soluble salt. A pH of about 6.5 appears to be the critical point for zinc hydroxide. When the pH is below this point zinc corrodes rapidly by uniting with the negative ion responsible for the low pH. As the water in most boilers is above this pH, the rapid corrosion of zinc in hot-water lines and in boilers (zinc metal is occasionally placed in boilers to aid in retarding corrosion) is due to the hastening of the chemical reaction by heat, and also probably to the fact that the coating formed does not adhere to the metal so tightly as when the temperature is low. It is well known from practice that zinc is not suitable for high temperatures, and the reason is probably due to its failure to form an impervious membrane.

Zinc hydroxide has the power of either adsorbing or precipitating with it as a solid solution certain negative ions. If sulphuric acid is added to a solution in contact with zinc metal to the extent of forming about 200 to 300 parts per million of zinc sulphate, a stable pH near 6.5 will be established within 24 hours, indicating that the reaction between the acid and the zinc is complete. If the flask is then allowed to stand for several months and an analysis is made of the solution, practically no soluble zinc sulphate will be found. Precipitation of zinc hydroxide after reaction with the acid is complete carries down with it a small amount of the sulphate. This is a characteristic of several other hydroxides such as iron and aluminum. Whether this has any bearing on the character of the precipitate formed is not known, but with the high concentration of negative ions other than the $(OH)^-$ ions in steam boilers, we are dealing with concentrated solutions rather than solutions containing only a few parts per million of soluble salts.

If the corrosion rate of zinc keeps on increasing as the temperature increases, it would be interesting to know what happens in

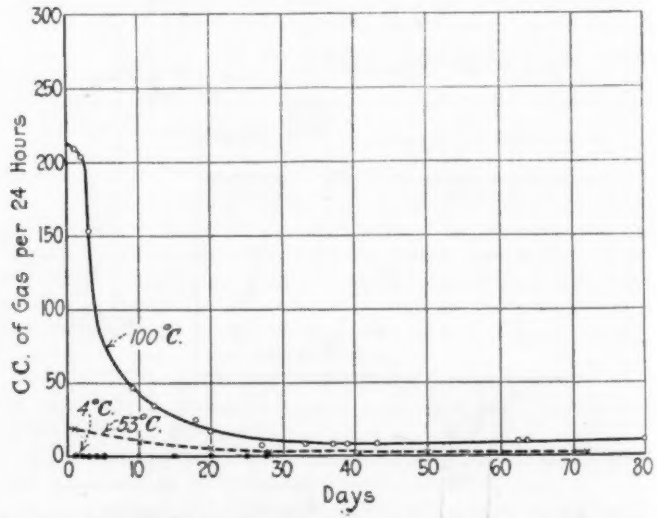

FIG. 4 HYDROGEN GAS LIBERATED FROM 50 GRAMS OF 20-MESH ZINC

boilers carrying very high pressures. Does the pressure have a retarding effect on the rate at which hydrogen gas is liberated? It probably does, or the corrosion rate would be so great at the high temperature of some boilers that it would be almost explosive in nature if it continued to increase as is shown by the trend of the curve in Fig. 3. The curves in Fig. 4 indicate that a coating is gradually built up on the surface at a temperature of 100 deg. cent., but it certainly is not formed so rapidly as for lower temperatures. So far no test on zinc at the high temperatures has been continued to the point where no hydrogen gas was being given off.

CONCLUSIONS

The liberation of hydrogen gas may be used as a measure of the corrosion rate of iron and zinc in the absence of dissolved oxygen. The rate of gas liberation increases as the temperature increases, at least up to the boiling point. In the absence of negative ions other than the $(OH)^-$ ions, iron becomes passive very rapidly, even at high temperatures. The initial tendency for zinc to corrode by the liberation of hydrogen gas is greater than for iron. Protection of the zinc metal is dependent to a greater extent on the surface coating formed by the products of corrosion than is the case with iron. Zinc is not suitable for temperatures higher than about 75 deg. cent.

[2] Baylis, Jour. Am. W. W. Assn., vol. 5, June, 1926.

Modern Sawing Machinery

Motorized and Belt-Driven Machines—Rip Saws—Cut-Off Saws—Combination Saws—Dado Machines—The Electric Hand Saw—Choosing the Saw—General Discussion—What the Future Holds

By J. A. McKEAGE,[1] MONTROSE, PA.

BEFORE launching into the actual discussion of the various types of sawing machinery, it must be explained what constitutes the difference between a motorized and a belt-driven saw. The illustrations accompanying this paper show both motorized and belt-driven machines, but it must be understood that they are simply those submitted by the manufacturer for reproduction and do not represent a demand by the author for any particular type of drive. As a matter of fact, actual purchase could be made of them in either form. While the tendency of design is unmistakably toward the motorized machine, as will be shown later, belt drives are still in the large majority.

The belt-driven saw is as old as circular-sawing machinery itself, but it was not until 1919 that the motor-on-the-mandrel came into demand. During that year, one of the largest manufacturers of automobile bodies demanded that they be supplied with planers, matchers, and stickers having motors direct on the cutter head. This led to the further demand for sawing machinery built along the same lines. The idea spread rapidly, and at present writing over 50 per cent of all new sawing machinery is directly motorized.

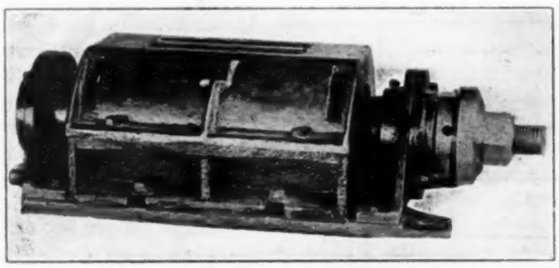

Fig. 1 Woodworking Motor-Mandrel Unit, 5 Hp., 3600 R.p.m., with Bearings Separate from Main Motor Housing

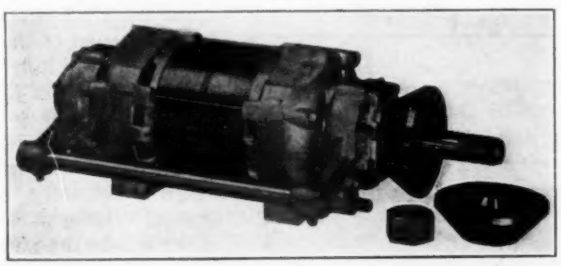

Fig. 2 Motor-Mandrel Unit in Which Steel Shell Is Exposed and Bearings Are Unit with End Shields

The motor supplied to the manufacturer for this type of equipment consists merely of a separate stator and rotor, the stator being a small-diameter steel shell which contains the laminations and windings proper. The manufacturer mounts the stator in a housing to suit his particular needs, pressing the rotor on to the saw mandrel proper and letting the mandrel serve as the rotor shaft. When completed and assembled, the finished motor-mandrel unit looks as depicted in Figs. 1 and 2.

The outstanding characteristics of these woodworking motors are their small diameters, permitting comparatively large saw projection, their application of full power direct on the blade, their smooth high-speed running, and the minimum attention required by them. The two motor units illustrated represent two distinct types. Fig. 2 shows one on which the steel shell of the stator is exposed, the shell fitting snugly into the two end shields which house large ball bearings. The feet of the end shields are planed off flat, permitting this unit to be used as a separate installation on a great number of machines.

The motor in Fig. 1 is of rather unique design, having its bearings separate from the motor housing proper. Either or both of these bearings may be taken down without disturbing the remainder of the unit, they and the motor housing being doweled into position. For cleaning, it is only necessary to remove the four cap screws holding the cover of the split motor housing after which this cover may be lifted off and the entire inside of the motor exposed. The base of the motor is supported on three points or feet, as shown, making a three-point-suspension mounting, which is very adaptable to wooden-frame machines and others subjected to constant moving about and jarring.

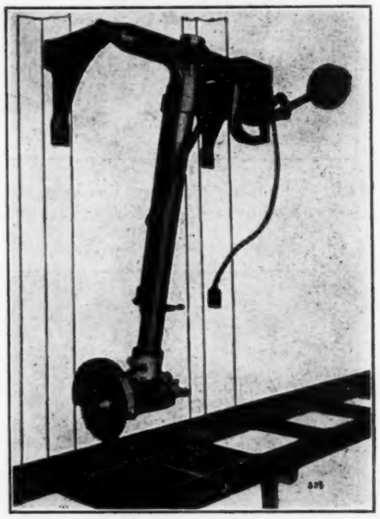

Fig. 3 Overhead-Type Swing Cut-Off Saw with Counterweights to Return Saw to Original Position

The construction of the ordinary saw mandrel for belt drive is familiar to every one, and detailed discussion will not be gone into except to state that both bronze and babbitt bearings are in wide use, the latter being the more common. Wick oiling from a reserve chamber is generally resorted to.

Classifying the Machine

All sawing machinery may be roughly classified under four headings: cut-off saws, rip saws, combination (or universal, variety, or tilting-table) saws, and dado machines. The latter, usually combined with the cut-off, ripping, or combination feature, might be placed under any of the other three headings, but for the purpose of this paper, dado machines will be classed separately. Within the last two or three years the steady use of portable and bench machines has led to the subdividing of all the above four classes into two types: stationary, and portable or bench. Since the operating features of both the large and small machines remain identical, they will be explained and discussed together.

Cut-Off Saws and Trim Saws

Cutting off and trimming may be performed by any one of three distinct methods of sawing, and for each method there is a separate type of machine: (1) The work may be placed upon a stationary table top and the saw moved across it; (2) the work may be placed upon a stationary table top, and, guided by suitable gages, pushed by hand into the saw; (3) the work may be placed upon a *moving* table top and pushed into the saw. Without doubt the greatest percentage of cutting off is performed by the first and third methods. All three have their uses and advantages, and no one particular method could be discarded entirely and be completely substituted for by one or both of the other two.

With the work on a stationary table top and cutting off effected by a moving saw, the machine for so doing generally carries the name of a "swing cut-off saw" or "straight-line cut-off saw." There are several types of these machines, one of the most common of which is shown in Fig. 3. This particular illustration shows a motorized machine, although belt-driven swing cut-offs are in wide use. The whole affair swings about a bearing overhead, at a long radius of 5 to 7 ft., giving the blade an arc which approaches close

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to a straight line in its short swing. The column on such a machine is so mounted and balanced that it will swing back into position of its own weight after cutting, or by a system of counterweights.

Another type of swing cut-off saw is placed *under* the table instead of overhead, the principle of operation being exactly the same. Still another type has the saw moving in a straight line. In this case the arbor is mounted on ball-bearing gibbed ways or some other method just as suitable, and is drawn forward by a foot pedal or hand lever sliding on and guided by the ways as it advances. The saw may be swiveled about its column, permitting the cutting of a miter. As a rule these types of machines are built in the motorized style only, as some difficulty in belting is experienced where heavy belts are used. However, one successful belt-

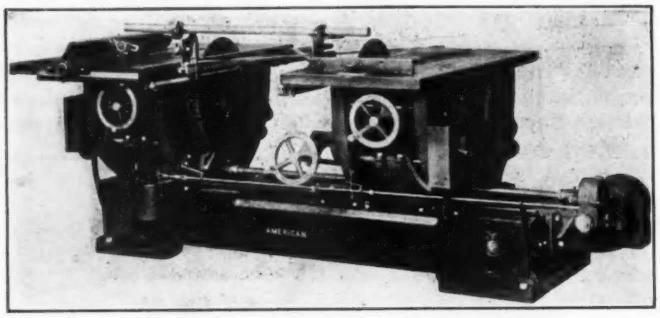


Fig. 4 Double Cut-off Saw Employing Two Separate Adjustable Saw Mandrels with Rolling Skeleton Carriage Between for Trimming and Cutting-Off

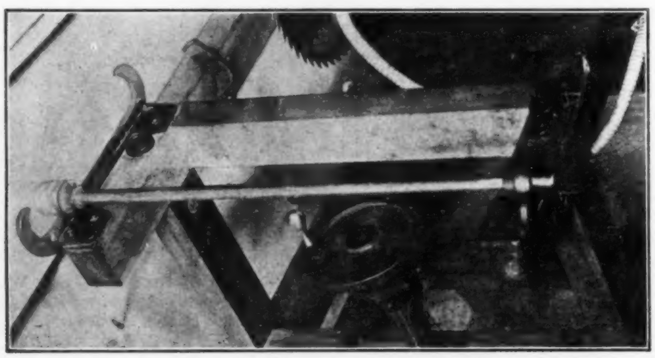


Fig. 5 General Arrangement of Rolling Device for Tables and Carriages—The Anti-Friction Roll

Fig. 6 Details of Anti-Friction Roller Shafts for Rolling Table Tops and Carriages

driven machine of this style will be discussed later (see Fig. 21.) As in the case of the swing cut off saw, the saw travel is limited, but is very commendable for cuts not exceeding 20 in. or so.

When the work is placed upon a stationary table top and pushed by hand into the saw, being guided by some suitable gage, absolute accuracy is not always obtained unless the yoke type or double gage is used. On account of the inability of correctly supporting the work on both sides of the blade when a single cut-off gage is used on one side, great variations in the finished cut will be obtained until two gages are yoked together *over* the saw. Again, unless the work is comparatively light and short, cutting off with this sort of machine is not productive. Long and heavy work requires the service of at least two operators. However, it has the advantage—when the correct gage is used—of cutting a compound angle very accurately and may be said to be indispensable for this type of work.

The rolling-table cut-off saw generally consists of a rigidly mounted arbor, over or past which rolls a carriage or table top carrying the work to be trimmed or cut off. Figs. 4 and 5 illustrate two machines employing this method. The rolling carriages on saws of this type employ one of four distinct kinds of rolls. As a rule, a complete roller shaft unit consists of a V-shaped roll and track on one end and a flat roll and track on the other. Fig. 5 shows the arrangement of such a unit, the details of which are given in Fig. 6. The V-track acts as a guide and serves to keep the table traveling in a straight line, the flat track merely acting as a support on the other end, the flat roll traveling in unison with the "V." The "anti-friction" roll is shown in Fig. 6; another type is shown in Fig. 7. It derives its name from the fact that no oil is required for operation and the only friction is rolling friction. On this particular type of roll, the section A is shrunk on to the roller shaft RS, the section B being loose and made adjustable to fit the V-track. This movable section is held in place by a setscrew after proper adjustment is obtained. The upper track UT is fastened to the bottom of the table top TT, and the lower track LT to the frame of the machine F.

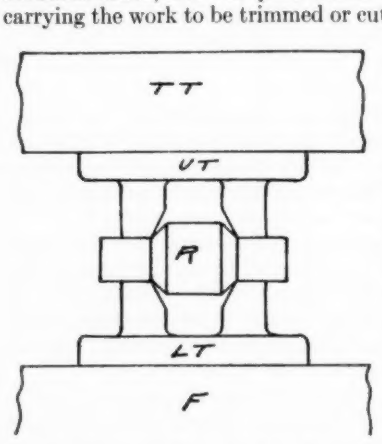


Fig. 7 Another Type of Anti-Friction Roll

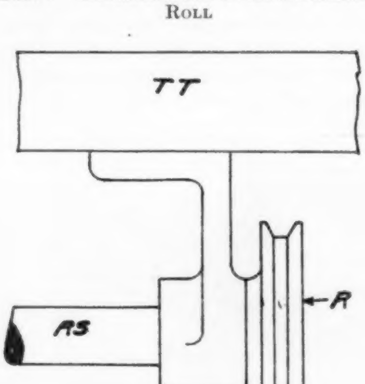


Fig. 8 Roll Which Employs a Bearing in Which to Turn

The roll in Fig. 8 is mounted on the shaft RS, which turns in the bearing bracket fastened to the under side of the table top. This roll requires oil in the bearing proper. Like the anti-friction roll, the other end of the shaft carries a flat roll traveling in step with the "V," and turning through a bracket bearing. Still another type of rolling device is illustrated in Fig. 9. Here the upper and lower tracks consist of planed slots or ways which roll on steel balls. The illustration is self-explanatory and shows the method of construction and operation plainly.

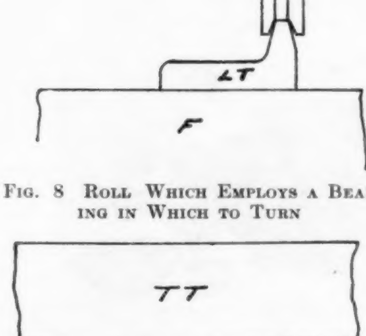


Fig. 9 Device Employing Grooved Ways and Steel Balls for Rolling Tops and Carriages

Cut-off saws with the rolling-carriage feature have several distinct advantages and one disadvantage. They are absolutely accurate in every cut, can be built for any desired length of cut or carriage travel, and may be operated from any point along the carriage. On the other hand, they take up considerably more floor space than the swing cut-off saw. Due to their extreme accuracy on long cuts, they are the only type which have proved a complete success in trimming wide veneer panels.

Multiple-stop cut-off saws with rolling carriages may be obtained in either wood- or iron-frame construction, and in any travel desired. The usual carriage travel on this particular type of saw is between 24 and 30 in., and will suffice for all ordinary trimming. The work is placed upon the carriage and up against the correct stop; the carriage is then moved forward, pushing the material into the saw. Practically the only force required for its operation is that which is actually necessary to pass the work through the blade.

Fig. 4 depicts a double cut-off or multiple cut-off saw. It is very accurate, and on account of its having a long travel is sometimes called a trim saw for panel and veneer work. The machine consists virtually of two independent saw benches, mounted on a common base. These saw benches are adjustable to and from each other in order to obtain required distances for panel and veneer trimming. The telescoping carriage between is mounted on anti-friction rolls and carries the work between and past the saws. This machine has some very commendable features and is in wide use.

Another type of double cut-off or trim saw, practically indispensable to the veneer and panel trade, has independent multiple saws which are carried by adjustable sleeves on the mandrel and may be slid along and locked into place where desired. Any number of saws may be used for multiple cutting off and trimming. The carriage is mounted on anti-friction rollers, which are compounded three to one in order that a narrow carriage may be used for extra long lengths of travel. Narrow sliding beds are provided to move up against the saw blades on either side and support the work being cut off or trimmed. This machine is very accurate and is extensively used for trimming and cutting wide veneer panels to size; the machines for so doing are built with carriage travels sometimes over 100 in.

In addition to the hand-fed cut-off machines, there are the automatics which carry the work forward and past the saws by the endless-bed method, see Fig. 10. This endless bed generally consists of an open chain carrying dogs at set intervals and traveling between the blades. Where the number of pieces to be cut off runs into large numbers, or where the separate cuts number high, these machines are time and money savers. However, the very nature of their design calls for material to be cut off which is light enough and small enough to be fed rapidly, otherwise the advantage of the automatic feature is lost.

Choosing a Cut-Off Saw

Before purchasing a cut-off saw there are two all-important points to be considered: namely, the type of cutting-off to be done, and the machine space available. If the head room is available, the overhead type will give nearer a straight-line cut than the underneath or floor type. On the other hand, low ceilings often make the floor type absolutely necessary.. The straight-line cut-off is low and compact and takes up but little more space than either of the swing cut-offs. In the author's opinion, the actual space occupied by any of these three machines is so nearly alike that unless the ceiling room makes a serious difference, the choice actually lies with the operator.

Since the swing cut-off and straight-line machines make but one short cut and must be operated at the point of the saw, the saw with cut-off carriage with multiple stop is often preferable. This machine takes up more floor space, but is very accurate and rapid, and may be operated from any point along the carriage. For double and multiple trimming, on long or short cuts, machines such as shown in Fig. 4 must be employed.

Rip Saws

Before opening the discussion on rip saws, it must be explained that the safest and most efficient ripping is obtained when the saw blade is just allowed to peep above the work being pushed through. The blade should not project through more than $^1/_8$ or $^1/_4$ in. at the most; and compensation for various thicknesses of wood must be made either by vertical adjustment of the saw mandrel itself, or by the raising and lowering of the table top. Therefore the one outstanding feature of a successful rip saw is its ability to adjust the projection of the saw blade above the table top for various thicknesses of wood.

Rip-sawing machinery may be divided into two main classes: hand-fed machines, and self-feeding machines, the latter containing machines having two distinct types of feeding mechanisms, roll feeds and endless-bed feeds.

The oldest and simplest type of rip saw is easy to build and is within reach of the smallest customer. The frame and table top are accurately constructed of hardwood, the frame having mortise-and-tenon joints, and the table top being made up of narrow strips of kiln-dried maple, glued, finished straight, and then cleated to prevent warping. It is generally equipped with an arbor. Lately, the motorized machine, an application of which is shown in Fig. 11, has been much in demand.

While the rip saw just mentioned is very reasonable in price and is simple in construction, necessary saw adjustment is compensated for by raising and lowering the table top which is hinged at the rear and guided in front by slotted irons. This is a serious disadvantage in that when proper adjustment is accomplished for thin stock, the table top has such a decided slant from front to rear that the operator is immediately in difficulty, and, if remedy by smaller saw blades is attempted, shutdowns for the changing of saws are frequent and annoying. The two main advantages lie in the fact that these saws are cheap and might easily be arranged with any size or shape of table top for special work. Sometimes sliding cut-off gages are inserted in the table to provide for cutting-off work, but such an arrangement is not highly efficient or productive.

In higher types of hand-fed machines the saw adjustment is accomplished either by raising and lowering the table top or by raising and lowering the saw arbor itself. Either method is satisfactory. These machines may be obtained in either wood- or iron-top styles. As a general rule they are for heavy duty and their frames are of iron. The author has very often seen this type of machine with specially shaped or very wide wooden table tops for special work, armored with sheet steel to give the everlasting wearing qualities of iron. Such construction is very successful.

The commonest and oldest of the self-feed rip saws is the roll-feed type. Late developments along these lines are illustrated in Fig. 12. These roll-feed machines are equipped with stationary arbors, which are located under the table top, and are commonly arranged for either hand ripping or self-feeding. For hand ripping, the feed works are raised clear of the table and out of the operator's way. Saw adjustment is accomplished by raising and lowering the table. The higher types of machines have both their infeed and outfeed rolls power driven, the lower rolls idling and following the work as it passes through. The feed is driven either through a series of belts, chains, gears, or combinations of such. The chain method is most in vogue, although other drives are in use and are very successful. Three feeding speeds are usually furnished, these ranging between 30 and 160 ft. per min. Of course higher and lower feeds are furnished and may be obtained upon request, but the ranges given will cover the majority of cases.

These machines are productive and economical both from the installation as well as the operative point of view. On account of the impossibility of getting a dead-true surface with the roll feed, it is generally employed either for sawing out rough stock or material to be finished afterward on the jointer. However, with a high-speed mandrel and a fine-tooth hollow-ground blade, very satisfactory surfaces may be obtained with proper feed and roll adjustments. They may also be used for gang ripping—ripping timber into several different strips by employment of several saws and spacing collars; but for gang ripping on a proper production basis, a regular gang rip saw should be used. Here both the upper and lower rolls are power driven, assuring the correct feeding of the multiple pieces after cutting. As the power required will be directly proportional to the number of saws employed, the machine must be constructed to withstand heavy continuous loads.

The very latest developments in the heavy-duty self-feed rip saw is represented in the endless-bed machines under the names of "chain-feed rip saws," "endless-bed rip saws," "straight-line edgers," and such. Here the feed is accomplished by an endless bed made up of separate links. Several types of these machines are shown in Figs. 13, 14, and 15. Two distinct methods of design are evidenced; those with the saw units *overhead*, and those with the units *underneath*. The principle of operation in each case

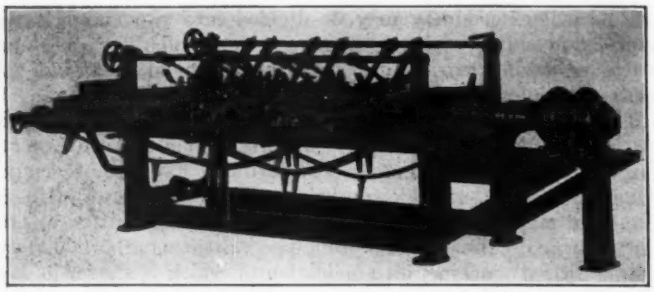


FIG. 10 AUTOMATIC DOUBLE CUT-OFF SAW

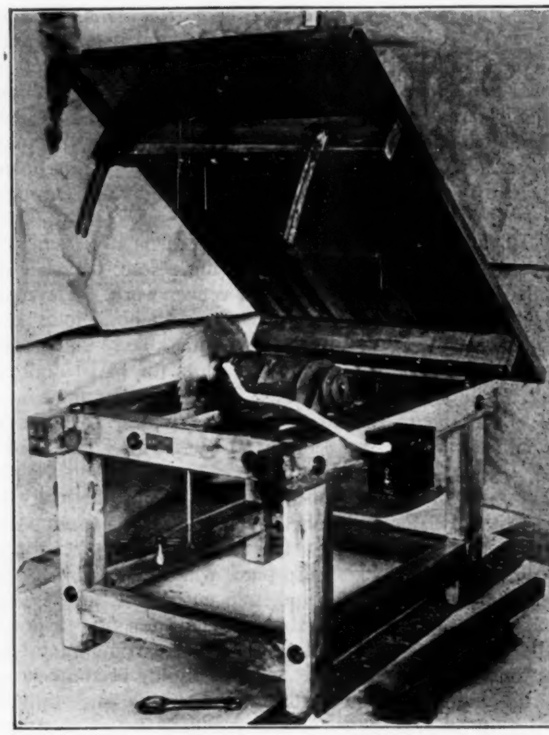


FIG. 11 SIMPLE TYPE OF MOTORIZED RIP SAW—HARDWOOD FRAME AND BED

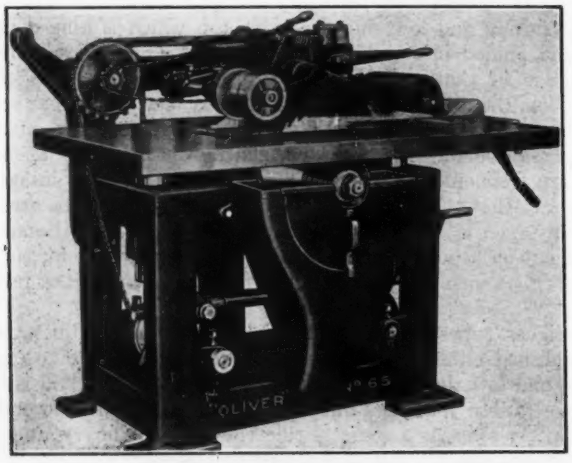


FIG. 12 SELF-FEED RIP SAW—ROLL-FEED TYPE OF LATE DESIGN

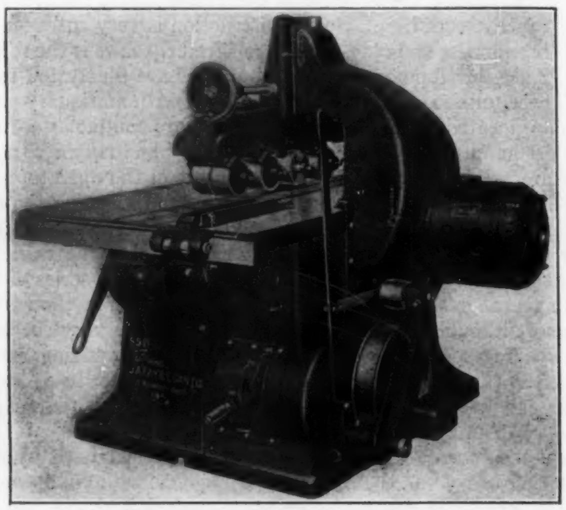


FIG. 13 UNDER-SAW TYPE OF ENDLESS-BED RIP SAW

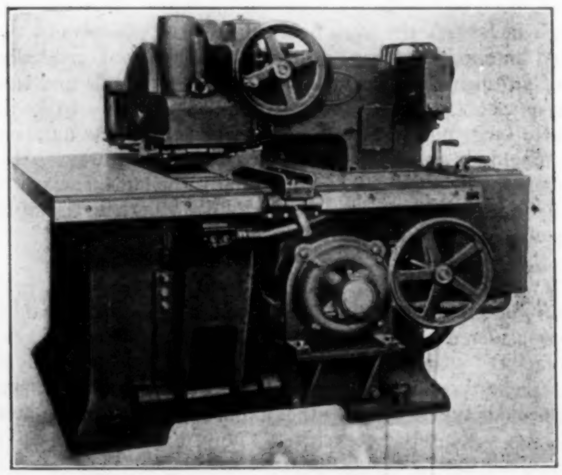


FIG. 14 LATE DESIGN OF HEAVY-DUTY ENDLESS-BELT MACHINE—OVERHEAD SAW

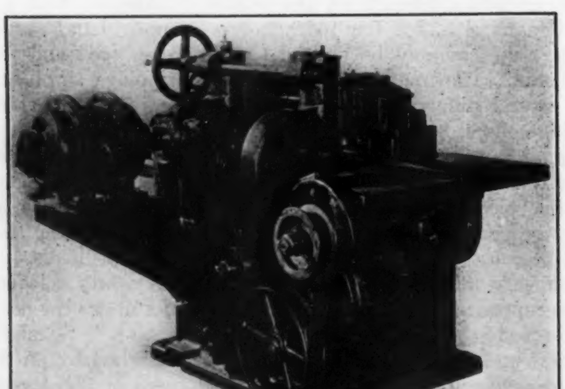


FIG. 15 METHOD OF DRIVING ENDLESS BED—COMBINATION OF BELT TO GEAR REDUCTION—OVERHEAD SAW

FIG. 16 HEAVY PEDESTAL-BASE TYPE OF DOUBLE-ARBOR TILTING-TABLE SAW

remains the same: Pressure rolls hold down the work on to a moving endless bed which carries this work through the saw, moving in a dead-true line and cutting an accurate kerf.

The feeding mechanism is driven either by a separate motor as illustrated in Fig. 14, or by belt-to-gear reduction as shown in Fig. 15. The manufacturers maintain advantages for both the overhead and underneath saws, some of which sound very reasonable while others smack of sales talk. The fact remains, however, that both types are very efficient and productive. On account of the heavy duty demanded of these saws, they are massive and will withstand severe abuse. It is even possible to cut perfect glue joints with them when using hollow-ground blades and a medium-slow feed.

Choosing a Rip Saw

The problem of choosing a rip saw rests merely with the answering of two questions: How much work is there to rip per day, and how good a machine can be afforded?

Analyzing the question from all angles, a few brief points may be stated (1) With but a small amount of ripping to be done each day, the small shop would be foolish to purchase any other than such a machine as illustrated in Fig. 11. (2) Where there is a great deal of hand ripping, it is economy to purchase a better type of saw. (3) Since there are very few shops on a heavy-production basis which do not have both a large amount of hand ripping as well as "form" ripping, it is most economical for these shops to have a good hand-feed machine as well as a self-feeder. The type of self-feeder depends entirely upon the class of material to be worked. Chain-feed machines are a great deal more expensive than roll-feed machines. On the other hand, chain-feed machines will trim a bark strip in a dead-true line where roll-feed machines must follow and

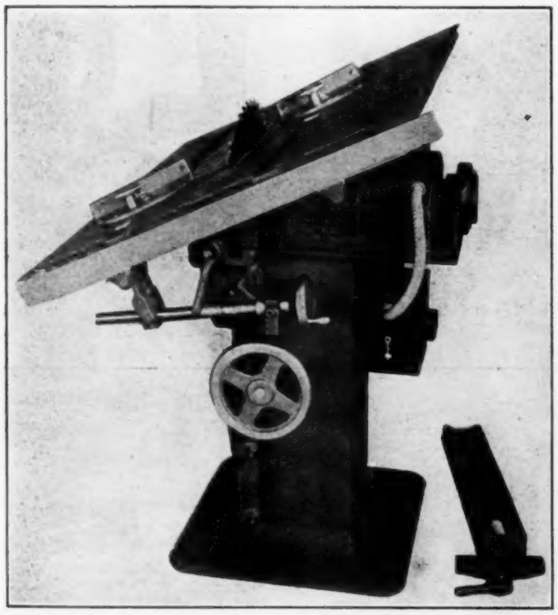


Fig. 17 Single-Arbor Tilting-Table Saw—Motor on Saw Mandrel

feed to a gage. The choice of this particular type of self-feed rip saw is entirely up to the customer, and his needs must be analyzed before actual purchase. Space does not permit the author to bring out all points to be considered, but should any of the readers be further interested, unbiased recommendations will be gladly discussed and given through correspondence.

Combination Saws

As the name indicates, this machine is so designed as to perform ripping, cross-cutting, or dadoing. In other words, it is for general variety work and often carries the name of variety saw or universal saw. There are really three distinct types under the heading of combination saws: tilting-table saws, combination rip and cut-off saws, and universal woodworkers. The latter, on account of generally incorporating a band saw, jointer, shaper, and other such attachments, is really in a class by itself for all practical purposes.

Of all sawing machinery used, the combination machine constitutes the largest majority. It is used extensively by the "little fellow" who desires one good machine to perform all his woodworking operations and is working under a limit of both capital and floor space. On the other hand, the larger mills also have places for these combination machines as they will always perform work which

Fig. 18 Fastest Combination—Rolling Table Top and Double Arbor

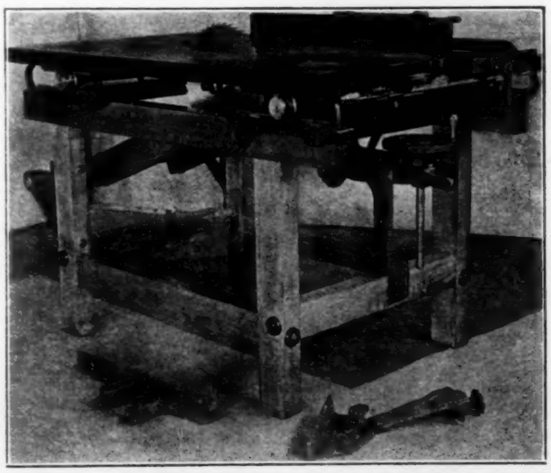


Fig. 19 Single-Arbor, Wood-Frame Combination Rip and Cut-Off Saw with Rolling Table Top

cannot be economically done with a straight ripping saw and cut-off saw.

Tilting-table saws are made in single- or double-arbor types, with pedestal or cabinet bases. All their table tops are arranged to tilt to an angle of at least 45 deg. Slots are cut the entire length of these tables which are fitted with sliding cut-off gages, allowing either a square, miter, or compound miter to be cut. Some table tops are made in sections, permitting cut-off work to be done in a manner similar to the rolling carriage. Fig. 16 shows a double-arbor machine with the pedestal-type base. A pedestal-base single-arbor saw is shown in Fig. 17. With the exception of the wooden throat piece all tilting-table saws are made of iron and steel throughout.

Of all the combination rip and cut-off saws, the fastest machines in the world undoubtedly are the combinations of double arbors and rolling table tops such as illustrated in Fig. 18. Here there are two distinct arbors, one carrying a rip saw and the other a cut-off saw or dado head, etc. The table top is mounted on anti-friction rollers as previously discussed and illustrated in Fig. 5. When ripping is done, the table top is blocked stationary, but when cross-cutting is desired the release by a locking lever immediately converts the table top into a rolling platform. Since the saw blades are already in position and ready for use, a change from one

to the other is effected by turning a small handcrank—one saw disappearing beneath the table and the other appearing in its place. This change is all accomplished while the machine is running full speed, there being no lost time for shutdowns or the changing of saw blades. A further advantage is the application of a table extension which allows the operator to handle long lumber without assistance. In other words, the machine is a "one-man" machine, and in all the author's experience he has yet to run across a more efficient and rapid combination than that shown. For alternate ripping and cutting off, such as shipping-room and crating-floor work, this, and also the single-arbor type as shown in Fig. 19, cannot be excelled. The latter is identical with the double-arbor except that a single arbor is used instead. These machines can be obtained both in the wood and iron frame, belt and motor driven.

Combination saws under the heading of universal woodworkers are shown in Figs. 20 and 21. The type in Fig. 20 generally has a band saw, jointer, shaper, and hollow-chisel mortising and boring attachment in addition to the saw bench, which really makes it fall outside the scope of this paper. However, it might be mentioned that where floor space is limited, and where a self-contained wood shop is desired, such as on shipboard, in lofts, etc., this machine is indispensable. Fig. 21 shows a combination which also carries a jointer and borer, making it universal in the broad sense of the word. It will be noted that the method here used for cutting off consists of a sliding saw arbor *belt driven*. On account of the light weight of the belt, this method is successful and very handy. When ripping is done, the cross-cut saw is pushed back out of the way, the table top lowered to the correct position, and the belt changed over to the pulley of the rip saw. While this machine may be

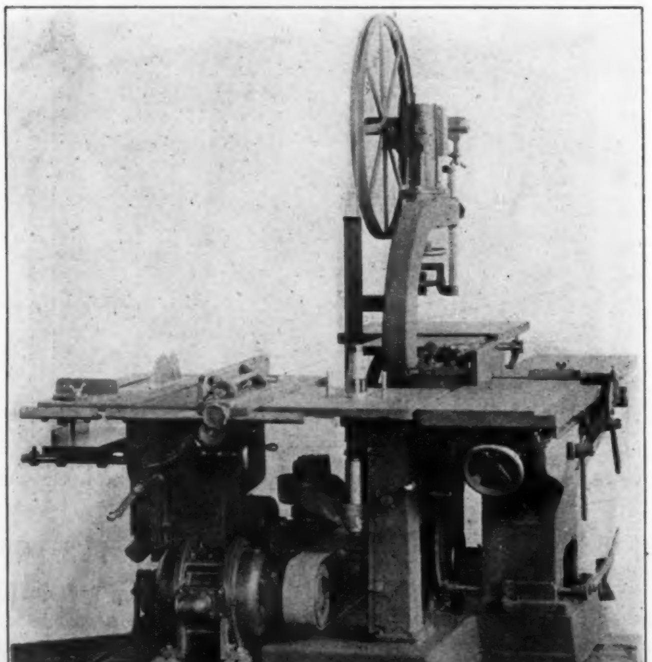


Fig. 20 Universal Woodworker with All Attachments—Really a Wood Shop Complete

classed under the portable type, its duty is really heavier than that of the ordinary bench machine.

Choosing a Combination Saw

In this choice perhaps the most important question is: What class of work is there to do? Since a combination machine is not generally used for high-production on straight ripping and cross-cutting or dadoing, the final choice will be governed chiefly by the quantity of this or that combination of work to be performed. Thus, for a pattern shop or cabinet shop where small and intricate work is desired, there is no doubt but that a double-arbor tilting-table saw is the most efficient for these needs. On the other hand, if there is a quantity of alternate ripping and cross-cutting, such as might be found in any small shop catering to building trades, or in shipping rooms of large manufacturers, etc., the fastest machine made for this class of work is the combination machine with rolling table top and double-arbor feature. Where a combination blade is used, the single-arbor machine in this construction is also very efficient and commendable. For limited space in places desiring machines to perform more than sawing, no machine can take the place of the universal woodworker.

Dado Machines

The two main features necessary in any machine for dadoing are ability to adjust the saw arbor and accuracy of feeding the work. Strictly speaking, dado work on a production basis requires a special machine for so doing, but nearly all combination machines will be found designed to carry and operate dado heads. Tilting-

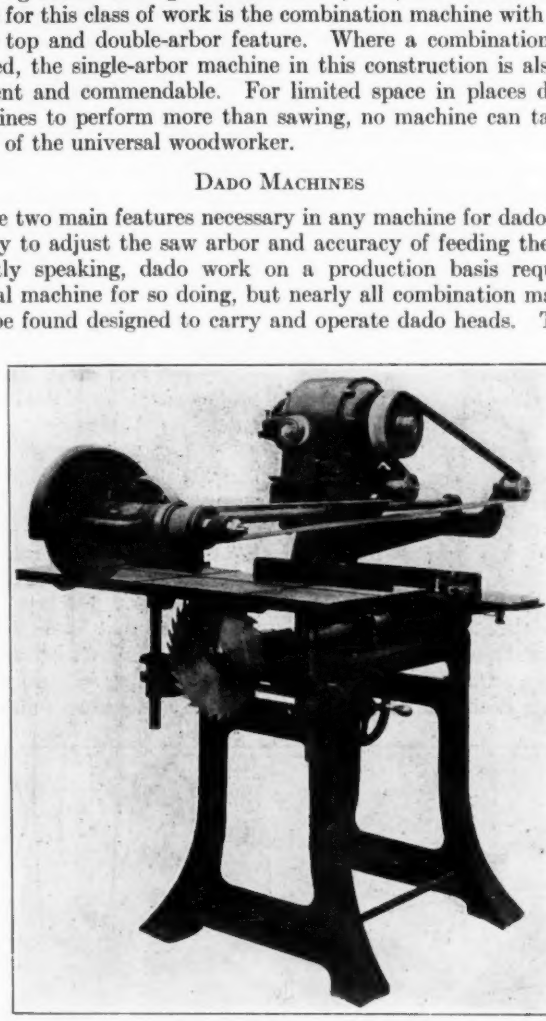


Fig. 21 Handy Type of Universal Woodworker for Lamp-Socket Operation or for Small-Powered Motors

Fig. 22 Combination Gang Dado and Equalizing Saw—Carriage Adjusts Vertically—Saw Mandrel Carries Any Number of Saws and Dado Heads

table saws feed their work over their dado heads by means of sliding cut-off gages. Machines having rolling table tops *roll* their work over the heads, this method probably being the most accurate known for hand dadoing.

Fig. 22 shows a machine for carrying multiple dado heads and saws, the carriage being mounted on roller shafts and capable of vertical adjustment. Another model employs a rolling carriage also, but in this case the *arbor* is adjusted vertically instead of the carriage. Both these machines are very efficient and accurate hand-feed machines, which may also be used for trimming and cutting off. Machines for strictly dado work and trimming are illustrated in Figs. 23 and 24. The first is a horizontally fed ma-

chine and the latter one fed vertically. Both are very accurate and productive, especially for sash and door work. The illustrations are self-explanatory as to the general construction of the machines. The beveled slot as shown on one end of the dadoed window frames is obtained by feeding out and away with one of the motors as the work proper is fed down.

Choosing a Dado Machine

In a sash-and-door plant, where the work is in very large quantities and in comparatively small widths, or in furniture factories for the same class of work, there is no doubt but that the automatic is the fastest and most productive machine. However, for multiple dadoing, or multiple combination trimming and dadoing, or for accurate long cuts, the machine with the rolling carriage is to be preferred. In this place it must be mentioned that in addition to the machine illustrated in Fig. 24, a similar machine but with saw arbor *overhead* is manufactured. The main advantage of this type of machine lies in the fact that the pressure of the cutting has a natural tendency to hold the work down on to the carriage as against the holddowns necessary for its rival. On the other hand, with the arbor overhead, there is more time lost in head changing and more tendency toward vibration. However, this machine also has the feature of giving any carriage travel desired.

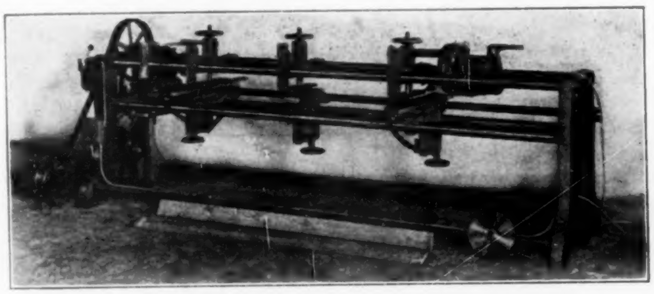


Fig. 23 Automatic Horizontal-Feed Trim and Dado Machine

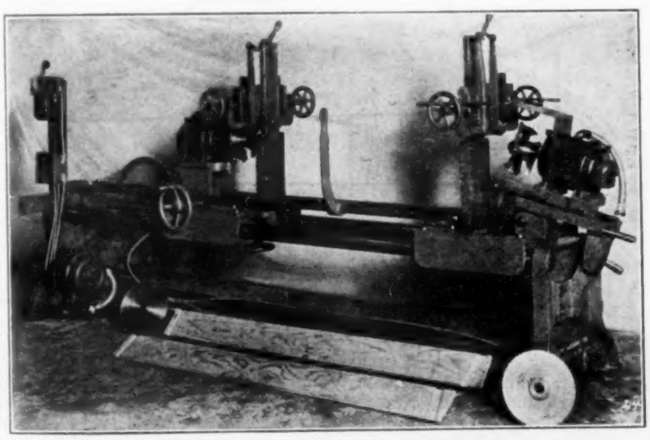


Fig. 24 Automatic Vertical-Feed Trim and Dado Machine—Beveled Slot Is Obtained by Feeding Right-Hand Motor Out and Away as the Work Is Fed Down

Bench Machines

The last year or two has brought out a tremendous demand for the small portable and bench machine. These are made in almost every form conceivable, but since their general operating features embody the same principles as those of the stationary types, it is unnecessary to go into detailed discussion again. On general assembly floor work, or finishing floor work, in cabinet shops, furniture factories, sash-and-door plants, etc., they are time savers and are proving to be indispensable. They save countless footsteps to the larger machines, and hours of hand work at the bench.

These small machines are relatively new in the trade, and the "old timers" often scoff at them as being merely playthings. However, like the automobile, they have graduated from the luxury class and are becoming real necessities, and in the author's opinion within a few years they will become as common in a well-equipped shop as the stationary saw is at present. Fig. 25 shows a portable type made to move around the shop to any convenient place for operation. It is pulled about by a handle similar to that of an ordinary factory truck. Small universal or single-phase motors are usually employed for lamp-socket operation. Fig. 26 shows the latest development in the bench line in the shape of a small swing cut-off saw. It is unique and compact. The bench machine illustrated in Fig. 27 is of the tilting-table type.

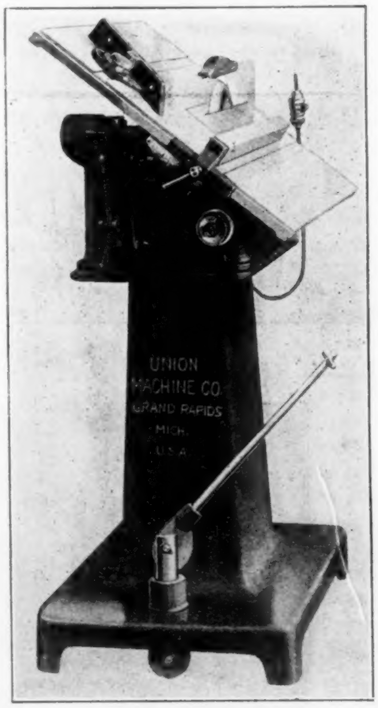


Fig. 25 Portable Combination Machine for Lamp-Socket Operation

The Electric Hand Saw

A tool destined to revolutionize hand sawing wherever electric current is available has recently been introduced to the trade. It is the electric hand saw, one type of which is shown in Fig. 28. A small universal motor is geared through worm and wormwheel to a saw spindle on ball bearings. Saws 8 in. in diameter are used, which are capable of cutting to a depth of $2^3/_4$ in. Since the entire assembly is light and easily controlled, very rapid and beautiful work may be accomplished, saving a great deal of laborious handwork. Especially to be mentioned is the adaptability of this machine for cutting into old flooring and removing sections of it without scoring and cutting the joists as in the case of an ordinary hand saw.

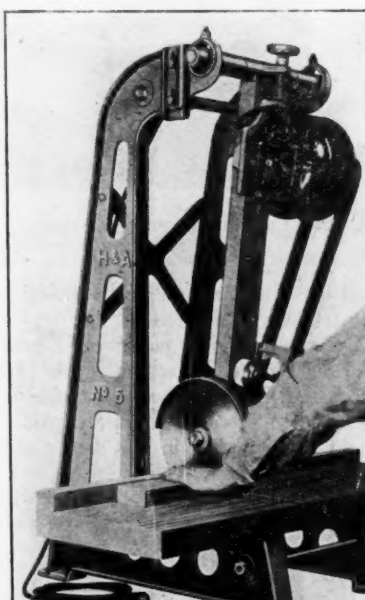


Fig. 26 Bench Type Swing Cut-Off Saw

Special

Possibly outside the scope of this paper is a tenoning machine which is especially adapted to the sawing of tenons such as shown in Fig. 29. Very intricate tenons may be made on this type of machine, the work being fed through and past a series of blades set in the correct positions to perform all the cutting necessary in one operation. A rolling carriage guides and carries the work.

General Discussion

There is no doubt that at present all sawing machinery is evolving from belt to motor-mandrel drives. The author took great pains to gather data from all sections of the United States on the general trend of sales in second-hand and new sawing machinery for both the belt-driven and motorized types. At the present time over 50 per cent of all new sales throughout this country are directly motorized or motor-equipped. In some sections this percentage is considerably higher. A rather curious point to note is that in sections of oldest installations and experience, developments are slower and the sales of motor-equipped saws are considerably lower in percentage. Also, the problem of supplying customers with different

types of motors for their various currents has made distributors wary of stocking machines in sections where a common phase and voltage are not available. However, regardless of whether their ultimate purchase is a belt-driven or motorized saw, customers are found to be decidedly *in favor* of the new high-speed machine. Distributors and manufacturers are predicting that within the next ten years the entire sales of new sawing machinery will be of directly motorized or otherwise motor-equipped.

Even in the second-hand market where motorization of old belt-driven machines raises quite a problem, motorization before resale amounts to an average of nearly 20 per cent. This, together with the steadily increasing demand for motorized new machinery, proves that just as soon as the present used-machinery market is absorbed, and as soon as the present-belt-drive shops undergo overhauling, a complete turnover to the electric saw is assured.

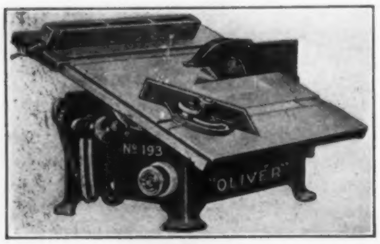


FIG. 27 BENCH-TYPE TILTING-TABLE SAW

FIG. 28 ELECTRIC HAND SAW—DIRECTION OF ROTATION TENDS TO HOLD MACHINE DOWN AGAINST WORK

In the author's paper on Circular Saws—Their Cutting on Various Woods,[1] the advantages of high-speed cutting are thoroughly discussed. A prominent saw manufacturer has declared that it is possible to produce a blade capable of 7000 r.p.m., but that the main problem lies in the steel's ability to withstand the severe work under such terrific speeds. This, however, in the author's mind, is a stumbling block which will eventually be removed, and he predicts that in the next ten years the 3600-r.p.m. blade will not only be universal for ordinary applications, but will be considered *slow* for fine work.

It seems that in average shops the first machine an operator chooses in the motorized line is the variety or combination saw. That is to say, his first thought in motorization is for universal work; which again goes to prove that experienced operators consider the high-speed machine essential to all classes of good work.

A great many of the older types of machines were of great weight in comparison to their duty and the actual strength necessary. Late designs are lighter in weight and yet heavier in their duty, their weights being so proportioned and balanced as to give great strength and rigidity where needed, and to eliminate that seeming clumsiness heretofore so noticeable. Like the automobile, the general "eye lines" or shape of the machines as a whole are rapidly changing over to the "straight-line" type, and there is no question but that they are more graceful and pleasing to look upon.

The growing scarcity of wood and soaring labor costs have made a demand on the manufacturer for machines to reduce the finishing cost and hand work to a minimum. This has only been lately possible with a combination of the hollow-ground blade, or planer blade, and the high-speed motor-mandrel unit. Thus, hand work and refinishing are gradually being eliminated on production jobs; and, with the advent of the small bench and electric hand saws, woodworking has at last reached the stage where further economy and efficiency can only be obtained by faster speeds, more automatic feeds where possible, and the elimination of human error when practicable.

AUTHOR'S NOTE: On account of the commendable features embodied in the various machines illustrated herein, the author finds great difficulty in discussing the advantages of these machines without seeming to sponsor some to the detriment of others. Since he is personally obligated to the different manufacturers for their coöperation and kindness in permitting their machines to be illustrated and discussed without apparent bounds or limitations, engineering ethics forbids direct comparison or the singling out of objectionable features. It should be distinctly understood that he has endeavored throughout the paper not to be biased in any way whatsoever.

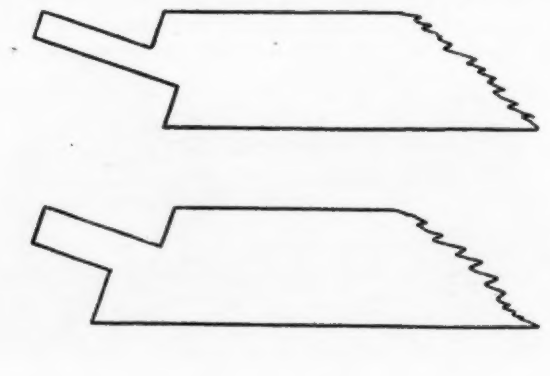


FIG. 29 EXAMPLES OF TENON WORK

A velocity of 3500 ft. per min. should be maintained in the center of a shavings exhaust pipe to prevent precipitation of the refuse on the bottom, where the velocity is lowest. This figure is based on the assumption that the usual mixture of planer shavings, sawdust, sander refuse, etc. is to be handled. To save power, branch pipes not in use should be closed, but care must be exercised in order that the air velocity may not be lowered to a point causing precipitation and clogging. The entrance velocity of hoods must be greater than that in the pipe line; around 5000 ft. per min. is considered safe. Machine hoods must be so designed that the material will be thrown in the general direction of the hood. Elbows must be long-sweep, to reduce friction to a minimum. No ell should have an inside radius of less than one and one-half times the diameter of the opening. Junctions of branches with the main should be as nearly parallel as it is possible to make them. The main should increase in size with each branch addition and the total length should be as short as possible, terminating on the exhaust side of the fan in a collector over the boiler room, if the refuse is to be burned. (C. C. Hermann, in *The Wood Worker*, Sept., 1926, p. 48.)

[1] See MECHANICAL ENGINEERING, vol. 48, no. 10, October, 1926, pp. 1005–1110.

Proposed Standard for Drawing Sizes and System of Numbers for Mechanical Drawings

A Discussion of Present Practices, with Recommendations Calculated to Overcome Existing Defects in Drawing Sizes, Filing Systems, and Identification of Parts

By E. KWARTZ,[1] SEATTLE, WASH.

EVERY drafting room has some sort of standard drawing sizes, as well as some system for the numbering of its drawings for filing purposes. Each piece requiring detailing also usually has a distinguishing mark or number. Pieces requiring patterns are given pattern numbers. Pieces going into a machine manufactured for the market should have numbers for replacement purposes. The above requirements are met in various ways, every drafting room, it would seem, having a system of its own.

In manufacturing shops, however, the system of making one drawing for each piece is apparently recognized as the best practice, and in many instances these drawings are made $8\frac{1}{2}$ by 11 in., or regular letter size. There are some considerable advantages connected with having this particular size; for instance:

1 The blueprints file or mail nicely with letters.

2 A standard letter file can be used for filing the blueprints.

It would be easier to introduce this than any other as a standard size, because letters are already standardized to $8\frac{1}{2}$ by 11 in. all over the United States and many drawing rooms now have, as already mentioned, their smaller details on $8\frac{1}{2}$ by 11-in. sheets.

There are some objections to the use of such small drawings; for instance:

1 Great numbers of such small tracings are annoying to handle in file drawers.

2 The blueprints of such tracings cost more per square foot than blueprints from larger tracings.

Objections to Letter-Size Drawings—Advantages of 18 x 24-In. Size

To overcome these objections it is advisable to make the tracings contain, say, four details. Referring to Fig. 1, it will be noted that four details occupying each $8\frac{1}{2}$ by 11 in. require a sheet 18 by 24 in. in size and leave a margin of $\frac{1}{2}$ in. all around the print, as well as a 1-in. extra margin on the left end for binding purposes.

It may be said, however, that a system of detailing each piece on a separate drawing is not necessarily the one best adapted for special work. At least from the standpoint of first cost of the drawings, one can make a set of detailed drawings of a special machine in less time by making the said details to as small a scale as possible and placing them as close together as possible, say, on an 18 by 24-in. sheet, and numbering the parts consecutively from 1 upward throughout, regardless of the drawing the piece occurs on. One would naturally aim to have parts that were closely related on the machine, occur as closely related as possible on the drawings. As an average, it would be found possible to have eight to ten details on a sheet 18 by 24 in. in size, using $\frac{1}{4}$ size for the scale of the parts wherever possible. Using such a system, one would not have more than about half the number of drawings resulting from the use of a minimum space of $8\frac{1}{2}$ by 11 in. for each detail.

In the production of a special machine not intended to be duplicated, it is probable that the shop will not be held to standard fits, limits, and tolerances, but that the parts will be more or less fitted to each other. When such is the case a drawing that shows in close proximity the parts that are to be fitted together has its advantages from the shop man's point of view. However, such a system should be considered as rather special, and it is not adapted, to the one-piece, one-drawing plan.

Referring again to Fig. 1, it should be noted that each detail is intended to have its own record, so there is no further need for the conventional drawing title at the lower right-hand corner. A number for the recording of the tracing is, however, in order, and this number appears on the tracing on the margin at the lower right-hand corner and upside down at the upper left-hand corner, to enable the number to be read if the tracing has been placed with the wrong edge out in the file drawer. The tracing numbers are on the margin rather than on the inside, for the very obvious reason that it is not desirable to have them appear on the detail prints when the blueprint has been cut up into shop details.

An 18 by 24-in. drawing will probably be found to be about the most common size in the United States, although for some very large details and for most general drawings it is too small. For such drawings, the author favors a sheet 24 by 36 in., which is just twice the size of the regular detail tracing. Either 18 by 24-in. or 24 by 36-in. sheets may be ruled into $8\frac{1}{2}$ by 11-in. detail sizes, but the advantages are with the 18 by 24-in. sheet, as follows:

1 The ruling of 18 by 24-in. sheets for $8\frac{1}{2}$ by 11-in. details will place the long side of the detail sheet horizontally and allow shafts, etc., to be shown.

2 The record of such a detail will be on the long side of the sheet and will, when filed in a vertical file, together with letters, permit reading without turning.

Objections to 24 x 36-In. Size for Detailing

Ruling the 24 by 36-in. sheet into $8\frac{1}{2}$ by 11-in. spaces places eight details on a sheet with a 1-in. margin around the large general tracing, but the details will be in the vertical position and rather narrow from left to right for most details. Such an arrangement of records does not work out well in a vertical standard letter file. Finishing the detailing of a machine should end the tracings in that particular series or class, whether the sheets are filled with details or not. It may so happen that the last part to be detailed must have an 18 by 24-in. sheet, when such a sheet is the standard size, and will unavoidably fill the upper left-hand corner only. Bad as it may seem on an 18 by 24-in. sheet, fancy the idea applied to a 24 by 36-in. sheet, with a small stud in the upper left-hand corner and seven remaining blank spaces!

Another objection to the large sheet is that one often wishes to start some parts through the shop, but must wait until the drawing is completed.

A 24 by 36-in. sheet of eight details takes more than twice the time required to prepare an 18 by 24-in. sheet of four details.

If an accident occurs to such a drawing while in process, or if for any reason it is necessary to discard the whole sheet, such a procedure is twice as expensive on a drawing with eight parts as it is on a drawing with four parts. Also, and very important, is the undesirable psychological effect on both the employer and the draftsman produced by working too long on a sheet.

The most serious objection to the 24 by 36-in. detail sheet for eight parts is inconvenience. The upper details are too far up for convenient work on the board, and if one traces the parts directly from assembly drawings and layouts, one has to shift such a tracing many times in order to keep it on the drafting board. For these reasons it takes a considerably longer time to produce eight details on one sheet 24 by 36 in. in size than it does to make eight details on two 18 by 24-in. sheets.

In any system of recording drawings and pieces it will be necessary to have either a record book or a card index, recording and classifying the various subjects drawn and assigning a separate

[1] Consulting and Designing Engineer. Mem. A.S.M.E.

Presented at a meeting of the Western Washington Section of the A.S.M.E., Seattle, Wash., January 22, 1926. Abridged. This subject is receiving the increasing attention of engineers in the various industries employing drawings for the guidance of work and the A.S.M.E. and Society for the Promotion of Engineering Education are acting as joint sponsors for the Sectional Committee now being organized to develop Standards for Drawings and Drafting-Room Practice.

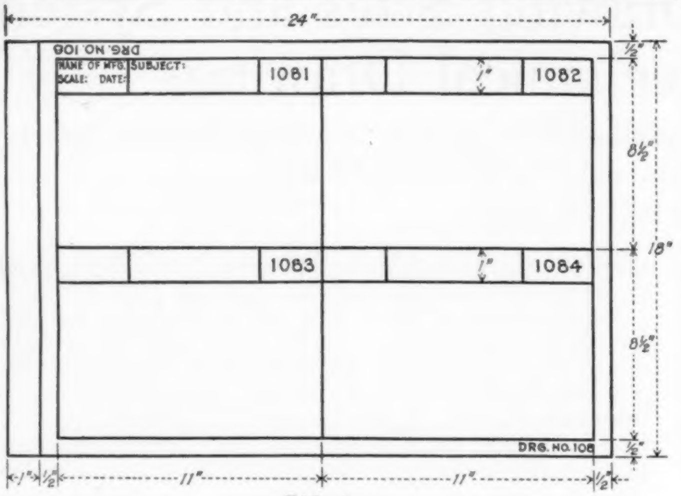


FIG. 1.

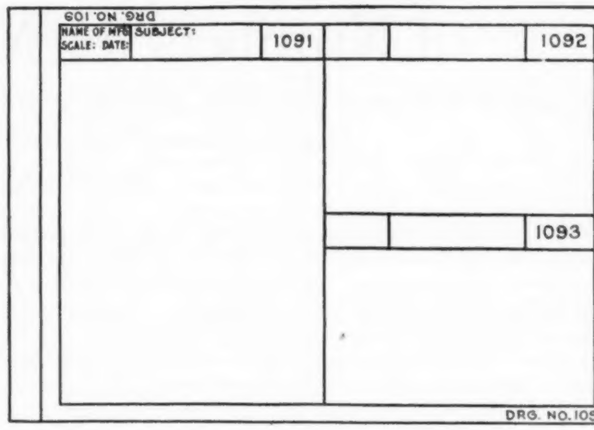


FIG. 2.

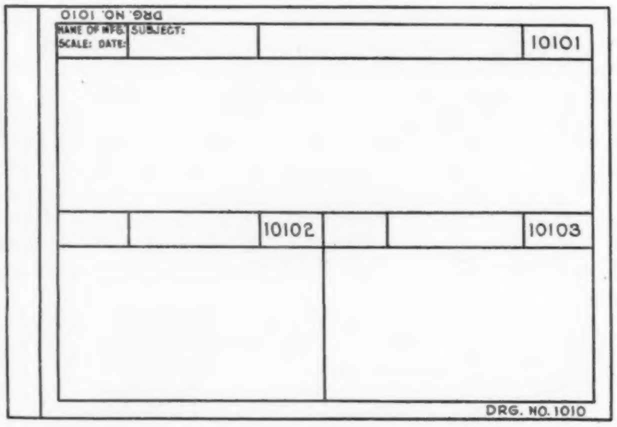


FIG. 3.

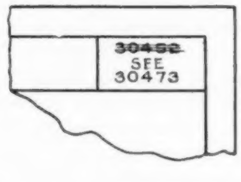


FIG. 4.

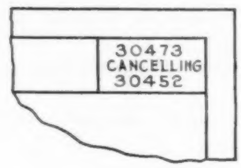


FIG. 5.

place of entry for the drawing numbers occurring under each class. For drafting-room reference purposes each machine should have a complete set of blueprints bound in a flexible cover, and 18 by 24 in. is a reasonable size for such a record book, all leaves being of one size, except for the possible necessity of binding some 24 by 36-in. prints, which should then be folded and bound on the left-hand half of the upper edge, but kept in their numerical places. Such a record book should also be furnished the general foreman or superintendent for his office use when a new machine is being built, so that he may be able to quickly and properly survey the whole job. This shop set should carry the order number under which the machine or set of machines is being built, later to be filed in the drafting room with all changes noted, thus making a permanent record of the machines as they were really built, regardless of alterations on the tracings. Figs. 2 and 3 illustrate the manner in which some details may occupy one-half of the 18 by 24-in. sheet lengthwise and other details occupy one-half the sheet crosswise. Sometimes it is even necessary to use the full sheet for one detail. In all cases, however, the record appears at the top of the sheet, so that it may be folded to $8^1/_2$ by 11 in. and the number in all cases be in proper position at the top in a letter file. It would be advisable on long details, however, to confine the title within the 11-in. length to the right, rather than to the extreme left as in Fig. 3, in order that the whole record may be visible even when a print is folded in the middle to go into a letter file.

Almost any establishment building machines in a variety of sizes, styles, and kinds is confronted by the necessity of keeping the records of the various kinds separate and distinct from each other. A drawing number or a part number should therefore have a classifying portion in addition to the number proper. With the system of drawing several parts on a tracing ruled into small details, it is desirable that the number of the part should indicate on what tracing it occurs. It is also desirable to avoid the use of the alphabet in connection with numbers, as it often is insufficient in characters and is open to other objections. There is also objection to the necessary dash in connection with the alphabet and numbers—the possibility of omission in copying, etc. For proper filing of drawings it is essential that the drawings under any certain topic, as size 1 or class 1 machine, be kept in rotation and in chronological order as they are made.

A New System of Numbering Drawings

In a scheme devised by James C. Porter,[2] the first digits indicate the number given to the kind, class, or size of machine to which the part belongs. These digits are followed by a zero, which serves to separate the class number from the number of the sheet. The number of the sheet follows the zero, and is followed in turn by the number of the piece. Thus, the number "20553" on a small detail drawing in the shop indicates that it is a detail for machine class No. 2 on tracing No. 55, and that the detail in question is No. 3 on said sheet. This system will work without confusion for any number of classes or kinds of machines, any number of drawings, and for up to nine details on each drawing. Drawings numbered according to this plan and made on different subjects and at different times will file consecutively and chronologically under the class of machines or devices to which they refer. Drawings thus numbered may easily be revised, or parts cancelled and the changes properly recorded.

If it should be desired, for instance, to cancel the drawing of a piece, say, No. 30452, one way to accomplish this would be to draw a line through the number in the upper right-hand corner;

[2] Commercial Draftsman, Seattle, Wash.

and if another drawing is made to illustrate the modified piece, the number of this piece and its drawing would be indicated under the crossed-over numeral, as illustrated in Fig. 4, which shows that this part is now made as per drawing No. 47, detail No. 3. On drawing No. 47 the number of the new part, 30473, would be followed by the cancelled number with a line ruled through it, as in Fig. 5, which is a precaution in two places against the wrong drawing's being used. The general title for each detail can be very simple and may be put on by means of a rubber stamp. A casual observer may contend that this numbering scheme makes an unnecessarily long number of a detailed part. Quite the opposite is true, as can be illustrated by the following example.

Assume that two hundred details of a special machine are required and that it is desirable to have the parts numbered consecutively, also that it is desirable to call this special machine class C. Suppose that we have to number in some adequate manner piece No. 150, appearing on drawing No. 45. The number denoting this piece that probably would occur to us would be C-45-150. In the plan described this piece would be 30453, which is five numerals, against eight characters in the assumed example.

In so far as the tracing file is concerned, if the standard drawing size be 18 by 24 in. whenever possible and the larger layouts and general drawings 24 by 36-in., these drawings will file nicely in the same file; the drawers being large enough for 24 by 36-in. sheets, with some of them parted in the middle for filing two sets of 18 by 24-in. drawings.

If it is desired to produce a set of details of a machine at minimum first cost, or a set of details of a machine entirely special and not intended to be reproduced, the system of standard sizes and numbers of details outlined is not the best; but in all other cases, be it for semi-manufacturing or large-scale production, the author believes it well worth considering. It has been adopted in a number of instances and is considered highly satisfactory.

Discussion

FOLLOWING the reading of the paper there was some discussion, during which several points of importance were raised.

Mr. Kwartz has submitted a written reply to the questions raised, in which he comments as follows.

There was some criticism of the part number, because of its length, the contention being that a great variety of numbers can be obtained by using one or two letters in different forms—for instance, AB or BA, a circle around A, or a circle around B, etc. That is true, but it is difficult to remember the significance of the letter combinations. The part number in the system described in the paper may be rather long; but that is because it contains valuable information which part numbers do not often contain, and precludes confusion of various kinds and sizes of machines. The part number need not become much larger, even in a very large establishment, because the number as arranged contains the possibilities of a great variety of changes.

The point was raised that the $8^1/_2$ by 11-in. sheet detail drawings did not provide a place for changes, in answer to which the author would say that the vacant space to the left of the number in the 1-in. top margin is a suitable place for such a record. However, when a part in a design is changed after the machine has been on the market, it is a question as to whether such a part should not have a new drawing and a new number in most cases, especially if it is subject to probable replacement from wear or breakage.

There was also some defense offered for the small individual tracing versus the 18 by 24-in. tracing containing four details. It was contended that the blueprints from such small tracings also could be bound into a book. That is admitted, but such a book would be considerably thicker than the same number of details on sheets containing four details, and, further, a generous provision at the left-hand margin of each small sheet must be provided for binding, which would take away considerable space. Not only that, but many details require a double $8^1/_2$ by 11-in., or a double 9 by 12-in. sheet, and in some work even the 18 by 24-in. sheet would be very small for detailing one part. In such an event such large detailed drawings would have to be folded several times to permit binding into the book, and such folding and unfolding would prove inconvenient and soon make an unattractive reference book.

A point in favor of a reference book of drawings with four details instead of one per sheet is that the former gives quicker access to a detail in a search, four details coming to view instead of one for each sheet turned.

One of the speakers described a system of numbering drawings in use in his establishment and in another local machine shop as an alternative scheme to that embodied in the paper. Their plan, he said, was to use small or large detail tracings as required, presumably one piece on a sheet. It is presumed that 9 by 12 in. was the smallest size, with 12 by 18 in. and 18 by 36 in. as the other sizes. A file drawer for each size of drawings was used and the drawings in each size numbered in serial order as they were made, regardless of the topic. This system had worked very well in his case, he said.

For an example to emphasize by comparison the merits of the plan of drawing sizes and numbers proposed in the paper, one could wish for nothing better. Assume a drafting room occupying a few draftsmen and designers on internal-combustion engines only, with designing work in progress on three or four sizes of engines. Jones takes out a number for a 9 by 12-in. drawing on size No. 1 engine. Smith takes out the next number for a 9 by 12-in. drawing for size No. 2 engine, the same process being repeated for other sizes of drawings. These various drawings of the various engine sizes could not be more thoroughly shuffled in the file. Suppose that it is desired to collect the set of drawings pertaining to a certain size of engine. One file drawer after another is examined until all have been searched. Even then one is not sure that the list is complete, for the drawings are not in numerical order. Any attempt to bind such a miscellaneous set of sizes will result in a very unattractive and inconvenient book.

In the system outlined in the paper there would be a large file drawer, divided in the middle, containing on one side 24 by 36-in. drawings and on the other side two compartments for 18 by 24-in. drawings; or there might be provided a file drawer large enough for 24 by 36-in. drawings only, in which case another file drawer would be necessary for the 18 by 24-in. drawings, this drawer to contain a central division and two compartments for 18 by 24-in. drawings. In the first case one drawer in the file would contain all the tracings belonging to a certain set of drawings. In the latter case two file drawers would be necessary. In either event a search through the 18 by 24-in. file would disclose all drawings in the order in which they were made. A missing number would indicate that the drawing was to be looked for in the 24 by 36-in. file.

Regarding the subject of drawing numbers, it is interesting to note the practice of one user of this system, who makes a practice of underscoring the drawing number proper, thus: Drawing No. 30<u>45</u>. While this is not necessary, it serves to set the drawing number out against the classification so that in sorting one's mind is relieved of contact with the remainder of the number.

With reference to minimum sizes of drawings, a quite common standard is 9 by 12 in. with 12 by 18 in. as the next size. These sizes also work with an 18 by 24-in. sheet divided into parts. If no margins of any kind are allowed around such a tracing, it will take four 9 by 12-in. or two 12 by 18-in. sheets. If it is not possible to agree on standardizing the smallest sheet to $8^1/_2$ by 11 in., at least a standard minimum size of tracing of 18 by 24 in., or 24 by 36 in. where the large size is required, can be adopted.

EXPORTS of industrial machinery from the United States during August amounted to \$11,820,610, as compared with \$14,687,489 for the corresponding month of 1925 and \$14,173,036 for July, 1926. It should be remembered that this trade is subject to wide monthly fluctuations, and although the trend is at present downward, the volume is nevertheless gratifying. A study of the figures published by U. S. Department of Commerce reveals a decline in all machinery groups with the exception of mining, oil-well and pumping equipment, which showed a substantial gain. The largest recession in exports was experienced in textile machinery, which fell off 43 per cent in August as compared with the corresponding month of 1925.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The "Shenandoah" Disaster

THE following remarks are taken literally from an editorial written a year after the disaster. The most significant statement is the one in which the writer says that "The airship is today as much a fair-weather vessel as ever it was," which, in his opinion, "spells their doom as practical means of transport."

"The cause of the disaster to the *Shenandoah* [says the editorial] stand out like a beacon from the pages of the court of inquiry's report. She was destroyed simply and solely by the action on her of external aerodynamic forces of an unusual kind. She fell a prey to rapidly fluctuating vertical currents of air which were unaccompanied by any visible sign at present recognizable by meteorologists. In her design she closely followed standard practice abroad. Her construction was in every respect sound. She was handled by a crew trained and experienced above the average. She did not fail, as did our own airship R 38, because those who built her stretched their practice beyond the limits of safety indicated by current theory. She was a vessel in which were crystallized all the fruits of man's hard-won knowledge of the atmosphere and how to transport himself through it. Yet after a brief and gallant struggle she succumbed to unforeseen and apparently unforeseeable natural forces. She was like a surface vessel tossed out of the water by the violence of the waves, to fall again and again until fractured by the impact. To allow for the effect of such a condition has never entered the thoughts of the airship designer; it may be doubted whether the possibility of the condition arising having been demonstrated, it will be found practicable to provide a structure of the bulkiness of an airship with strength sufficient to resist the accompanying shocks. It may be doubted whether any airship capable of rising off the ground could be built strong enough to surmount the forces which destroyed the *Shenandoah*. The airship is today as much a fair-weather vessel as it ever was. If the type is to be perpetuated without the recurrence of disaster such as that of a year ago, there would seem to be but one sure road to follow. We must learn how to read the signs of the weather with very much more certainty than at present, and be content to fly in airships only when the signs are favorable. In the opinion of many such a restriction of the flight of airships will no doubt be held, perhaps justly, to spell their doom as practicable means of transport." (Editorial in *Engineering*, vol. 147, no. 3687, Sept. 10, 1926, pp. 279–280, *g*)

FUELS AND FIRING

The Coking Propensities of Coals

Two methods for the investigation of the composition of coal, with special reference to its ability to be coked, have been described, one in 1916 by Fischer and Gluud, and the other in 1924 by Professor Bone and his associates. In this latter an electrically heated bomb working on the Soxhlet principle was employed and the extraction pushed to its end point. It is claimed that this latter method is superior to Fischer's, as in his process the liquid was continuously in contact with coal substance and hence liable to undergo chemical alterations. Moreover, by a certain new solvent treatment used in the Bone method, the crude benzene extract was divided into four and not two different fractions, of which I and IV were perhaps the more interesting from the point of view of the constitution of the coal.

Fraction I was always a thick reddish brown non-nitrogenous oil and exhibited no binding power at all. Fraction IV consisted of amorphous cinnamon-brown powders and exhibited considerable binding properties at 900 deg. cent. in admixture with nine times its weight of dry coal dust. It was found that the coking propensities of bituminous coals were approximately proportional to their respective yields of this fraction. It would appear, however, that some other factor besides the more intimate association of the chief coking constituents is required to develop the coking propensities of coal.

In the course of further researches upon the constitution of coal Professor Bone and his associates have been able to oxidize the "residues" from the benzene-extraction process by means of alkaline permanganate, obtaining large yield of benzenoid acids from which several aromatic acids have already been isolated in a pure condition, thus proving the essentially "benzenoid" structure of the main coal substance. (Prof. Wm. A. Bone in *Chemistry and Industry*, vol. 45, no. 36, Sept. 3, 1926, pp. 646–647, *eA*)

Burning Gasified Coal

DESCRIPTION of a system introduced by the Gasified Fuel, Ltd., 22 Bloomsbury St., London. The system is still in the experimental stage, but has been installed under a Paxman boiler in the company's own works.

In this system the coal is gasified by means of an incomplete combustion, and the resultant gas, with the air necessary for complete combustion, is introduced at the mouth of the furnace. In this way the temperature of the gasifying chamber is kept within reasonable limits so that the refractory lining is said not to be subject to severe usage, and the flame in the furnace proper is so distributed that trouble from the same cause is not experienced there.

The actual apparatus employed comprises a cylindrical brick-lined extension to each of the furnaces, together with the coal pulverizer, the coal being supplied to the furnace in the form of an impalpable powder.

The boiler in question is 8 ft. in diameter by 14 ft. 6 in. long and has two furnace tubes 2 ft. 8 in. in diameter with several Galloway tubes. The return tubes are 3 in. in diameter and the total heating surface is 1200 sq. ft. In front of each of the furnace tubes there is a gasifying chamber of approximately the same internal diameter as that of the tube and some 4 ft. long. These chambers are mounted on wheels, so that they can be withdrawn from the boiler if necessary. The chambers are lined with firebrick—quite plain in the case of the plant inspected—but it is intended that future sets should have hollow bricks, so that the gasifier may be air-cooled and the resultant hot air used in the combustion chamber. The pulverized coal, together with sufficient air for carrying it through the trunking, is delivered into the boiler end of the chamber, and a set of firebrick baffles so directs it that it first goes to the back of the chamber and then is discharged at the front into the boiler furnaces. The furnaces are, by the way, lined all round for a distance of about 5 ft. with firebrick plastered over with carborundum cement. Toward the back of the gasifying chamber there is a well at the bottom, in which slag may collect and be drawn off, either periodically or continuously, through a notch, as may be desired. At the end of the gasifier near the boiler there are three openings which admit the air required for the complete combustion of the fuel. Apart from the apparatus just described the arrangement of the boiler is normal.

In view of the difficulties which are experienced in getting under way with some special systems of firing, a test was made in which the boiler was started up from cold, after there had been no fire in it for several days. A few sticks were thrown into each of the gasifiers and lit with oily waste. The pulverizer was then started up and immediately began to supply powdered coal. This fuel burned with a deep orange flame interspersed with sparks, as seen through the secondary air inlets, but not a vestige of black smoke came from the chimney. After the fire had been burning about twenty minutes the sparks in the flame disappeared, and it was evident that the coal was completely gasified before it arrived at

the point where the secondary air was admitted. At this stage the lining of the gasifying chamber had become incandescent. The result was a big rolling mass of flame, which appeared to enter the furnace tubes equally throughout their area, while the cloudiness of the gases leaving the smokestack seemed to be caused more by dust than by smoke. In this connection it should be pointed out that the coal being used had, on account of the present strike trouble in the coal fields, been swept up off the local railway sidings, and consequently contained a very large proportion of combustible matter.

All of this material is not, however, discharged up the chimney, as some 30 per cent of the total is deposited in the form of slag in the gasifying chamber and is drawn off at the well already mentioned. Its temperature is sufficient to make it flow readily and, so far as could be judged, it contains practically no unburnt carbon. The flue dust does, however, include a proportion of carbon—about 9.2 per cent of its total weight.

The thermal efficiency of the boiler according to tests made at the plant works out at 76.2 per cent, with no credit given for the heat lost by radiation from the gasifying chambers. (*The Engineer*, vol. 142, no. 3686, Sept. 3, 1926, p. 256, 1 fig., and *Engineering*, vol. 122, no. 3164, Sept. 3, 1926, pp. 294–296, 9 figs., *d*)

HYDRAULICS (See also Power Generation)

On the Use of vd/v as a Parameter in the Practice of Hydraulics

THE author advocates the abandonment of all empirical formulas for the coefficient of frictional resistance in hydraulics and the substitution therefor of a series of curves determined by experiment giving the relation between $R/\rho v^2$ and log vd/v or log vr/v, each curve representing a particular degree of roughness in relation to the diameter. The author points out that such a series of curves are universal in character and apply equally to all fluids, gaseous or liquid, and at all temperatures. The work already done toward establishing the above relation is summarized in the paper, and the scope of further investigation which is necessary to increase the utility of the method is outlined. (E. Parry, *World Power Conference*, Sectional Basle Meeting, 1926, No. 3, Section A, 11 pp., 2 figs., *g*)

INTERNAL-COMBUSTION ENGINEERING

The Plenty-Still Steam-Oil Engine

THE original Still engine was described in MECHANICAL ENGINEERING, vol. 44, no. 5, May, 1922, p. 316, and the improved Scott-Still engine in vol. 47, no. 6, June, 1925, p. 504. In the Plenty-Still engine the makers have aimed at meeting the demand for an oil engine of greater power, but with reduced capital and maintenance costs. Fig. 1 shows a cylinder of the typical Plenty-Still engine of 130–150 b.hp. It has a cylinder bore of 370 mm. (14.5 in.) and a stroke of 450 mm. (17.7 in.), and is built for speeds of 220 to 250 r.p.m. and with 2, 3, 4, 5, and 6 cylinders.

One of the most important advantages of the engine lies, by virtue of the introduction of steam at the "cold" end of the cylinder, in the reduction of the temperature gradient between the cylinder ends, thereby, it is claimed, affecting considerably both the capital and maintenance charges. The maximum steam pressure is 150 lb. per sq. in. Another advantage is that the compression pressure is considerably reduced as the result of the higher initial cylinder temperature.

An important feature is the absence of inlet and exhaust valves on the internal-combustion side, the respective operations being controlled by ports in the cylinder, air inlet (left), and exhaust (right). The sloping surface of the piston top, raised at the air inlet side, enables the exhaust to be discharged before the air inlet port is opened. The fuel inlet valve is mounted in the center of the cylinder cover. This is housed in a case which is held by means of four springs on suitable seatings in the cylinder cover, thus forming a cylinder relief valve.

The fuel feed is of the solid-injection type and a specially designed cam-operated pump is attached to one end of the crank chamber. The system is unique in that the pressure on the fuel is constant during the whole period of injection and the injector itself is only under pressure during the actual period of injection, thus eliminating any risk of fuel being injected at the wrong moment.

The starting and maneuvering of the Plenty-Still engine are carried out by steam, which is obtained from a small auxiliary boiler,

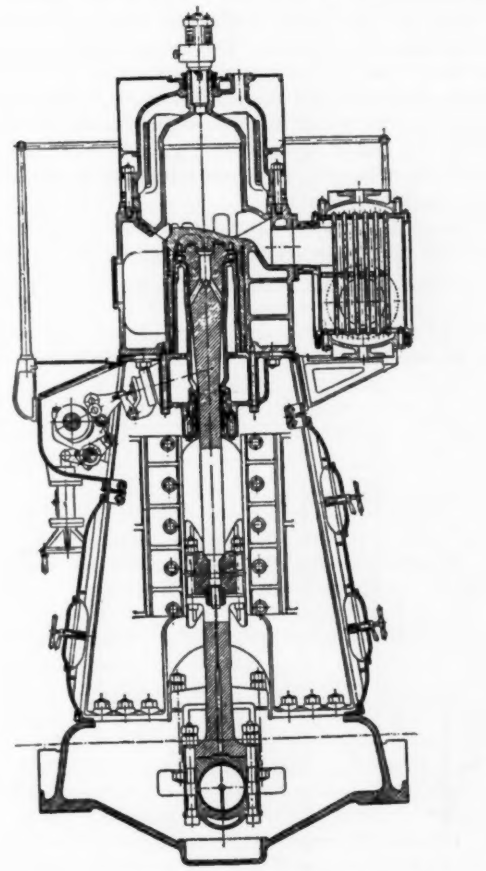


FIG. 1 SECTION THROUGH A CYLINDER OF THE PLENTY-STILL ENGINE

and if desired the engine can be run indefinitely at low speeds on steam alone. (*Gas and Oil Power*, vol. 21, no. 252, Sept. 2, 1926, p. 262, 2 figs., *d*)

15,000-B.Hp. Diesel Engine in a Single Station

AT THE Neuhof Station of the Hamburg, Germany, Electricity Works there is to be installed a 15,000-b.hp. engine of the M.A.N. type built by Blohm & Voss. The engine is of nine cylinders and runs at 94 r.p.m. The cylinders are in a row and in front of them is a two-crank three-stage injection pump supplying air for starting and for injection of the oil fuel. The two scavenging air blowers are arranged independently of the main engine and are driven electrically. The scavenging air enters the cylinder through ports controlled by the piston in such a manner that the air first of all passes over the piston head, is deflected toward the cover on the opposite cylinder wall having no ports, and finally, after repeatedly altering its direction, escapes through slots, which for the upper side of the cylinder lie above the scavenging ports and for the lower side of the cylinder below the scavenging ports. This is the regular practice of the M.A.N., and is claimed to work well with two-stroke engines.

The ruling principle in designing the engine from the point of view of stresses was to relieve the castings between the bedplate and cylinders from the tension stresses caused by the combustion pressures, and to eliminate axial stresses from the cylinder bodies and stuffing boxes in order to give them the possibility of expanding according to their state of heating. A strong frame results from the upright cast-iron standards and the bedplate and two transverse girders, in which the cylinders with their stuffing boxes are so held that they can freely expand. Long steel bars connect the upper transverse girder with the bedplate and transmit to it all stresses due to the combustion pressures in the upper sides of the cylinders. (W. Laudahn, Berlin, in *Engineering Progress*, vol. 7, no. 8, Aug., 1926, pp. 201–206, 8 figs., *d*)

LUBRICATION

Acidity Formation and Determination in Lubricating Oils

The author makes a distinction between inherent acidity and subsequent acidity. The former is due to the apparent commercial impossibility of removing all the acid from the oil in the process of manufacture of the latter. This type of acidity persists throughout the life of the oil, but is comparatively innocuous both because of low concentration and the character of the acids present. The subsequent acidity is due to oxidation and similar effects during the life of the oil, and is represented by such acids as formic, acetic, propionic, heptylic, etc.; these are strong acids and have the property of attacking metals.

With the above in mind a test was devised by means of which the rate of acidity formation could be determined. In this test a 50-cc. distillation flask fitted with a drawn-out tube was placed in an air bath at 150 deg. cent. (302 deg. fahr.), and oxygen at the rate of one bubble per second was bubbled through 10 grams of the lubricating oil under observation. This bubbling continued with the same temperature for 3, 6, and 9 hr., respectively, after which the flask was withdrawn and the contents titrated. The results are shown in Fig. 2. These results are substantially in accordance with the expectations, though the magnitude of the differences is striking. For instance, one would expect the paraffin or aliphatic series as represented by the Pennsylvania oils to be the most resistant to oxidation, and a naphthenic or heterocyclic oil as represented by a Russian oil to be the least resistant. The Mexican heavy lubricating oils consist of paraffins mixed with thioethers in small proportions; consequently they lie nearest to the more nearly pure aliphatic oil of the Pennsylvania type.

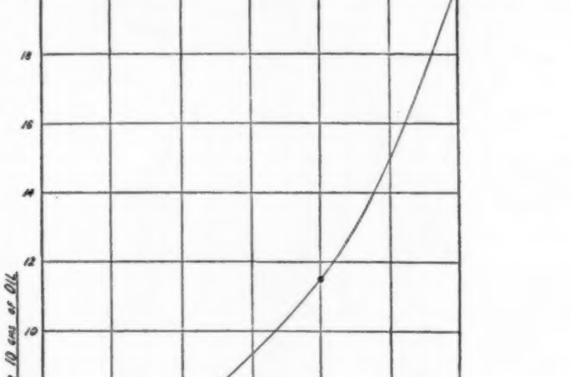


Fig. 2 Data of Subsequent Acidity Tests of Various Lubricating Oils

The author gives a table of various oils with their inherent acidity, final acidity, and what he calls Hackford's factor, which is the rate of acidity formation. The latter varies from 0.42 for a heavy medium cylinder oil to 15.9 for a heavy Russian Solar oil. In another test he found that the comparatively weak acidity of an unused new lubricating oil was at least partly soluble in water and capable of acting as an electrolyte. A standard recommended test to measure this effect is described in the original article. (J. E. Hackford in a paper before the *Diesel Engine Users' Association*, and published by the latter. Reference no. S 72, June 25, 1926, original paper, pp. 1–5, 2 figs., and discussion, pp. 6–19, *pe*)

MARINE ENGINEERING

Means for Improving the Efficiency of Propellers

The usual research on the efficiency of propellers deals with the problem of finding the best shape and dimensions for the propeller blades. The present author undertakes the consideration of the problem from a different angle, namely, that of increasing the efficiency of a propeller by utilizing the kinetic energy of the water rejected therefrom. A very simple way would be to find how to prevent the free flow of water from the propeller by opposing to it an artificial resistance. Imagine a wall perpendicular to the axis of the propeller and located quite close to it so as to receive the pressure of water projected astern by the propeller. It is evident that a more powerful action of the propeller would be required to handle the same mass of water in the same time. The question therefore resolves itself into creating an arrangement which would act like a wall parallel to the plane of the propeller and remain always at the same distance therefrom, but without increasing the resistance to the forward movement of the ship.

The author considers the problem mathematically and finds expressions of a comparatively simple character for the various elements entering into it. He then endeavers to embody the results obtained in a practical device. Theoretically an arrangement consisting of a propeller and a paddle wheel astern thereto, the axis of the latter being above the water surface, would increase the efficiency of the propeller. The resistance of such a paddle wheel, however, would be so great as to counteract the beneficial effect of the better action of the propeller. To meet this objection the author proposes the use of a device shown in Fig. 3 consisting of a power-driven propeller *a* and a loose propeller *b* running on an extension of the propeller shaft (Fig. 3). The water rejected by the propeller *a* strikes the blades of screw *b*, causing it to revolve with a certain velocity. If the diameters of the fixed and loose propellers were equal, the latter would operate only as a receiver. If, however, the diameter of the loose propeller is greater than that of the power-driven propeller, it will operate simultaneously as a receiver and as a motor, since the parts of the blades within the circle of sweep described by the power-driven propeller will act as receivers, while those which are outside of the circle will operate as motors and will attack the water which is in a state of rest. The resistance due to this latter action is exclusively a resistance to rotation and not one to forward translation. This resistance to rotation creates a resistance to the evacuation of the water rejected by the propeller, and from this results an increase of the resistance to propulsion and hence an increase in the efficiency of the propeller. (M. Baringolz in *Le Génie Civil*, vol. 89, no. 8, Aug. 21, 1926, pp. 156–157, 4 figs., *md*)

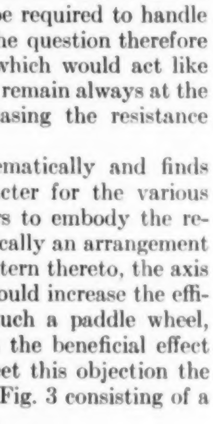


Fig. 3 Loose-Propeller Scheme to Increase Efficiency of a Marine Propeller

MEASURING INSTRUMENTS

Accelerometers

A recent development in the field of instruments is the accelerometer. Acceleration has been defined in two ways: (1) as a rate of change of velocity; and (2) as the force which accompanies the velocity. The present article describes a number of such devices of mechanical, hydraulic, and electrical types.

Of particular interest is the simple accelerometer known as the contact accelerometer, because it has been extensively used and can be applied to testing rotating machinery. It consists essentially of a weight held against a contact by a spring. At a certain value of acceleration the contact will be broken, the break being recorded by means of a voltmeter or other suitable means. With a battery of such instruments, each calibrated slightly different a record may be made so that acceleration between two limits can be determined. This type of accelerometer has been found practical in determining the upward acceleration of airplanes and elevators. (F. Paulsen in *Electric Journal*, vol. 23, no. 9, Sept., 1926, pp. 475–478, 12 figs. and bibliography of the subject, *d*)

MECHANICS

Effect of a Constant Torsional Stress upon Specimens Subjected to Repeated Bending Stresses

A paper largely descriptive of a machine designed by the authors, and giving results of tests carried out under the following conditions: (1) When the specimen was loaded as a rotating beam in such a way that a test length of 3 in. was subjected to constant bending moment; and (2) when a constant twisting moment was transmitted through the specimen. The results of the tests were of interest as throwing some light on the problem of the conditions of failure under repeated stresses. The experiments showed that an addition of a constant shearing stress to a bending stress, provided it was below a certain value, did not lower the number of repetitions to which a material could be subjected under cycles of bending stress. Taking results as a whole, however, the data obtained did not solve the vexed question how and why a piece of material failed under repeated stresses. It could be said that a constant shear stress below a value equal to the normal stress in one direction did not affect the life of the specimen, but when the constant shear stress exceeded the given value the normal stress range diminished rapidly. The problem was complicated by the fact that the maximum principal stress did not occur on the same plane as the maximum range. Analysis of the results indicated that shear-stress range was affected very considerably by the magnitude of the maximum shear stress applied by torsion. (Paper presented by Prof. F. C. Lea and H. P. Budgen before the British Association, Oxford, 1926, and abstracted through *The Engineer*, vol. 142, no. 3685, Aug. 27, 1926, p. 217, *d*)

METALLURGY (See Special Machinery: Elimination of Heat Treatment of Gas Cylinders in England)

MOTOR-CAR ENGINEERING

The Hanomag Light Car

Description of a car built by the Hannoversche Maschinenbau A. G. at Hannover, Linden, Germany. It was designed to sell approximately at the price of a heavy motorcycle and a side-car combination. To accomplish this certain unusual methods had to be resorted to. A single-cylinder water-cooled engine is mounted vertically to the rear end of the chassis with the crankshaft arranged parallel to the axis. A clutch and three-speed gear box are incorporated in an extension of the crankcase, the power being finally transmitted through the enclosed chain to a solid axle. No differential gear is incorporated in the rear axle, while the brake-torque reaction and drive of the rear axle are transmitted to the frame with two radius rods. The engine is claimed to develop 10 b.hp. at 2500 r.p.m. The pistons of electron light metal are equipped with three rings above the gudgeon pin. This is of the floating type fitted in the small end of the connecting rod by a bush. The gudgeon pin is fitted with buttons at each end, a practice that has been the cause of considerable trouble in more than one design.

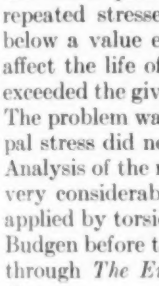


Fig. 4 Mechanical Starter on the Hanomag Light Car

No electric starter is provided, a simple and ingenious mechanical starter (Fig. 4) being arranged so that it may be operated by a hand lever on the left-hand side of the driver. It is intended to be operated by either the driver or passenger. When the hand lever is raised it operates the chain wheel *A* shown in the sketch between the two views of the engine through a single length of chain. This chain pinion is attached by a Woodruff key, which also carries a similarly mounted gear wheel *B*. As shown in the right-hand view, the gear *B* has several teeth milled away so that in the position illustrated it is not in mesh with the corresponding pinion *A*. Operation of the device, however, brings the gear *B* into mesh with the pinion mounted on the front end of the crankshaft, driving it through dogs engaging with the timing-gear pinion, which in turn is mounted direct on the crankshaft by a Woodruff key. When the starting handle is released a spring returns the gear *B* to the neutral position.

An ingenious feature of this device is the fact that the chain pinion *A* is fitted with a peg so positioned that when it is revolved in starting it immediately comes in contact with a catch, which, through a system of levers and rods, puts the contact breaker in the correct position for starting. (*The Automobile Engineer*, vol. 16, no. 219, Sept., 1926, pp. 318–322, illustrated, *d*)

POWER GENERATION

Economic Relation Between Electrical Energy Produced Hydraulically and the Same Energy Produced by Steam

Several papers on this subject were presented at the World Power Conference, Sectional Basle Meeting, 1926. The situation in America, and particularly in reference to the interconnected system of the Alabama Power Co. was the subject of a paper by Wm. E. Mitchell, vice-pres., Alabama Power Co., and John L. Gallalee, professor of mechanical engineering, University of Alabama.

Many different factors affect the economic balance between thermal and hydraulically produced electric energy. No general rules can be laid down. Each system or group of systems presents its own peculiar problems. The number, size and availability of hydroelectric sites and the necessity of developing them as a matter of public policy and fuel conservation may frequently outweigh any temporary advantage there may be on the side of the thermal plant.

On the other hand, the advancement in the art, the immense improvement in boiler and turbine efficiencies, the possible development of the mercury turbine, all tend to make the thermal plant a producer of energy at as low unit costs at all except the most favorably located hydroelectric plants. As long as coal is the prime source of heat, the thermal plant faces the certainty of increasing costs so far as this item is concerned.

For the territory with which the writers are most familiar, it would seem that for the next ten years, at least, the cheapest overall cost of energy will be attained by developing the hydroelectric plants considerably beyond their primary power capacity and supplementing these by economical steam plants located either at mine mouth or at important load centers. (*World Power Conference*, Sectional Basle Meeting, 1926, Paper No. 76, Section C, 47 pp. of text and several sheets of tables, maps and charts.)

The situation with reference to the steam turbines and conditions prevailing in Switzerland is covered by a report by Ad. Meyer and W. G. Noack, of Baden.

When all the various factors are taken into consideration, it can be said that even in countries where fuel is comparatively expensive, as for instance in Switzerland, steam-power plants are really on a competitive basis with water power. For instance, it is possible with the present coal prices to generate power in a 100,000-kw. station at the cost of 3.8 to 4 centimes per kw-hr. with about 2000 working hours per year, and for 3.2 to 3.4 centimes with about 3000 working hours per year.

Instead of burning good, but expensive, coal in stations close to the points where the energy is consumed, it would also be feasible to burn low-grade fuel, in which case, however, the steam-power station would have to be in the immediate vicinity of the coal field. In Switzerland, for instance, it would be possible to utilize lignite from the Rhenish deposits. Owing to the expense of the transmission, which is a chief factor determining the feasibility of a scheme of this description, the number of working hours is also here a decisive consideration.

If the constant load assumed for the steam plant cannot, for some reason, be maintained, and the power station is therefore subjected to considerable peaks or low loads of short duration, storage devices can be resorted to, which under certain conditions can be operated by the available electric power. For instance, the output generated in a hydroelectric station during the night can be converted into heat and supplied in the form of hot water to the boilers.

Combined steam power and heating plants have received of late an increasing amount of attention because they represent from the thermodynamic standpoint an especially rational mode of operating a heat plant. They are also of interest for steam power plants operating in conjunction with hydroelectric stations, since even in countries well supplied with water power, considerable quantities

of fuel have still to be imported for domestic and industrial uses, which could partly be replaced by exhaust steam from turbines. The period of maximum demand for heating in large communities would coincide with the usual periods of water shortage for the hydraulic plants. (*World Power Conference*, Sectional Basle Meeting, No. 79, Section A, 53 pp., 15 figs.)

Chief Engineer Alfred Büchi, Sulzer Bros., Winterthur, discussed the economic relation between hydraulically generated power and power generated from Diesel engines.

In Switzerland, he said, the production of power from Diesel engines for the supply of peak load is, independent of the price of fuel, more advantageous than the production of energy by water power if the ratio of the annually consumed kilowatt-hours to the peak load in kilowatts exceeds 2000 to 2500 hours. This is still more the case for the production of auxiliary energy, necessary in dry years only, and is due to the lower cost of a Diesel-power station, the possibility of erecting it near or at the place of utilization of the power, and its independence of the irregularities of water flow. It is most favorable to place the Diesel-power station in the proximity of large power consumers, who can be supplied by relatively short transmission lines at comparatively low voltage. The transmission of the power by means of high-voltage lines built for this purpose is economic only for short distances—approximately 20 to 25 km. in length. As the cost of production of power with medium and small Diesel engines is not very much greater than when large engines are employed, owing to the almost equal consumption of fuel and the slight increase in initial outlay, large power consumers such as cities and factories in minor industrial districts have an interest in erecting Diesel power stations of their own of small or medium capacity. If only peak-load power is produced by Diesel engines, the quantity and the cost of the fuel are of minor importance. Crude oil can be stored in tanks in such quantities so as to insure power production for a certain time. A further advantage of the Diesel engine is that it can be started within a few minutes at any time. Hence this engine is especially adopted for reserve power or for putting in operation in cases of emergency. In times of war and other troubled periods a Diesel-power station near the place of consumption can prove of great value for an undisturbed power supply. (*World Power Conference*, Sectional Basle Meeting, 1926, paper No. 38, Section C, 27 pp., 15 figs.)

In discussing German conditions, Franz Krieger, director of the Middle Isar Co., Georg Marx, professor at the Munich Institute of Technology, and Dr. Dieter Thoma, professor at the same school, treat first the economic conditions of thermoelectric and water plants independently, and then the interrelations of the two.

As the generation of current in Germany is being more and more centralized, the present investigations are limited to the large power stations. Examining the economic relations of the combinations of water-power and thermoelectric plants, the special characteristics of low-pressure water-power plants and storage water power are pointed out.

The results are then tested by investigating the conditions prevailing at the "Bayernwerk," where power is generated by low-pressure water-power plants, steam-power plants, and high-pressure reservoir stations, working in parallel. (*World Power Conference*, Sectional Basle Meeting, 1926, Paper No. 57, Section C, 23 pp. and 1 table.)

POWER-PLANT ENGINEERING (See also Power Generation; Steam Engineering: Pass-Out Steam Engine for Paper Mill)

Motor-Operated Valves

THE design of a high-pressure gate valve for motor control involves several special features. It is particularly important that a motor-driven valve operated by remote control should function perfectly at all times. Also particular attention must be given to the size, material, and design of the stem and to the connection between stem and disk. The torque obtainable from the driving motors is high, and without proper design the stem might be pulled out of the disk. Friction is minimized by ball bearings, and the use of machined guides in body and disk is essential.

The original article shows a number of typical motor-operated valves for various pressures and services. The drive consists essentially of a driving motor, reduction gears, and some type of limit switch. Valves closed while they are hot may stick on cooling. One effective method of supplying the force to start motor-operated valves under such conditions is to arrange the reduction gearing with a small amount of lost motion, so that the motor will come to speed before picking up the load. This results in a hammer-blow effect that will start any valve that can be operated by motor control. Another way of securing this effect is by the use of a suitable clutch, the motor coming up to speed before the clutch has time to engage, thus producing the hammer blow.

The closing time of motor-operated valves is a question much discussed by engineers; it will depend necessarily on the size of the valve, pressure involved, and desire of the user. Because of reactive pressures set up in steam lines and water hammer in water lines, too sudden closing is not desirable. One authority states that for carefully machined gate valves with ball bearings for the yoke nuts an average speed of 20 in. per min. for steam and water service is often used. Small valves, says another authority, may be closed in 15 sec. or less, while large high-pressure valves are often designed to close in $2^1/_2$ min. or more. Obviously, the higher the speed the less the torque available. Good practice therefore dictates a sacrifice of speed in favor of dependability. It is better,

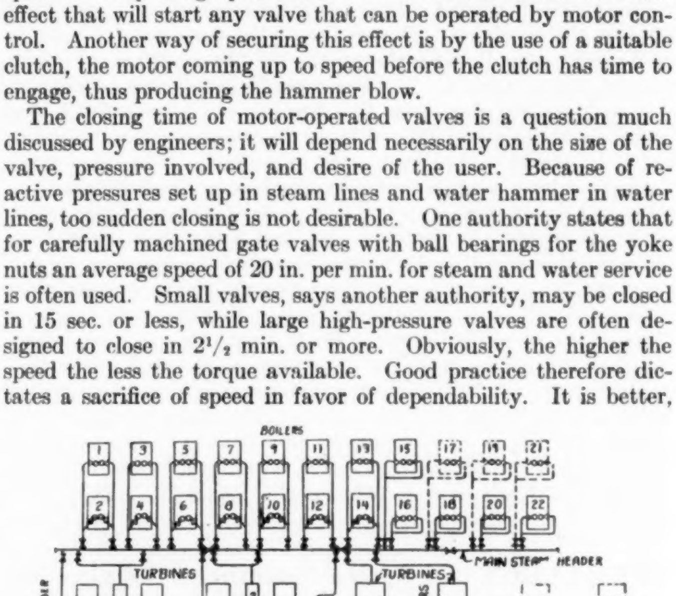


FIG. 5 DIAGRAM SHOWING LOCATION OF MOTOR-CONTROLLED VALVES IN A CENTRAL STATION THAT USES 101 OF THEM

in short, to be sure of closing in 2 min. under extreme conditions than to take chances of stalling a valve only partly closed at a higher speed.

The original article shows some original applications of large motor-controlled valves. One of these is a group of reheat valves on the reheat piping of a large turbine in a central station. Among these are one 26-in., one 30-in., and two 15-in. motor-operated valves. In addition to the usual control stations interlocking switches geared to the valves prevent the closing of one pair of valves before the other pair is opened. The 15-in. valves are on the bypass lines, and when open allow steam to go from high-pressure stages to the low-pressure stages without reheat. When these are closed and the 26-in. and 30-in. valves are opened, steam goes from the high-pressure cylinder to the reheat boiler and returns to the low-pressure cylinder. Since it would be undesirable to close the 15-in. bypass valves before the reheat valves were opened when changing over to reheat, the interlock switches were added.

Fig. 5 shows diagrammatically one of the largest layouts of electrically controlled valves in this country, installed in a large central station. At present there are 101 units installed, which, with their elaborate accessory control equipment, represent a total value of approximately $100,000.

From the centralized control board each pair of boiler-lead gate valves is closed simultaneously from one push-knob station with separate indicating lights for each valve. The same applies to each pair of turbine-lead valves. All valves are opened and closed from local wall stations.

The bleeder-heater control system employs 32 control units on 8 bleeder steam valves and 24 condensate valves. Each is controlled individually from local opening and closing stations. A

gage board in the turbine room includes eight push-knob stations operating the four valves for each of the eight bleeder heaters, so that any of the heaters may be bypassed at will. But this involves a special sequence of operation to prevent possible damage to the heaters. When the push knob for any heater is depressed, the steam inlet valve starts to close and the condensate bypass valve to open. When the latter is one-half open a special interlock closes the condensate inlet and outlet valves. To prevent serious damage to the main turbines, if the steam pressure of any heater should fail, permitting the condensate to back up into the turbine, a float switch is installed on each heater. Thus, when the water level in the heater rises abnormally, the valves operate automatically in the sequence just mentioned. (*Power Plant Engineering*, vol. 30, no. 18, Sept. 15, 1926, pp. 1001–1004, 4 figs., *d*)

A Preheating Pump

An article dealing chiefly with the type of pump made by Franz Seiffert & Co., Berlin, Germany. In this pump the boiler feedwater is heated inside the pump in direct contact with bleeder steam, the pump raising the pressure of the condensate of the prime movers fed back to the boiler from the pressure in the condenser to that of the boiler. It is claimed that the lack of the usual heat exchangers with all their pipes, pumps, valves, etc., results in a considerable simplification of the plant.

The preheating pump with which the author carried out a number of tests is a centrifugal pump designed for 3000 r.p.m. and 35 atmos. pressure, and consists of a low-pressure and high-pressure part, each of which contains several stages. In one of the installations the condensate derived from steam piping is introduced under different pressures into the various stages of a centifugal pump. In another design steam is admitted at both sides at the foot of the casing between two stages into specially designed chambers in such a manner that it condenses in the flowing feedwater. In still another type the steam is admitted to the water inlet on one side, mainly through the connecting pipe, between the low-pressure and high-pressure part of the pump. The article gives data of tests with such a pump. (Prof. E. Josse, Berlin, in *Engineering Progress*, vol. 7, no. 8, Aug., 1926, pp. 208–209, 3 figs., *d*)

Steam Reheating by Hot Oil or Mercury

Abstract of a British patent. The invention deals with steam-turbine power plants in which reheating of the steam is effected between the stages by the use of a fluid (for instance, oil or mercury) which serves as a carrier of heat from a place of supply, such as the boiler house, to the neighborhood of the turbine where in a heat interchanger it imparts heat to the steam. By controlling the speed of a circulating pump for this fluid, regulation of the reheating may be effected.

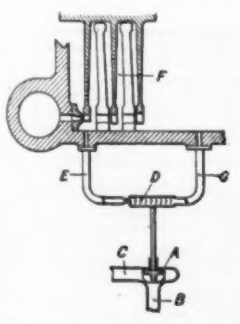


Fig. 6 Heat Exchanger for Reheating Steam Between Turbine Stages

This regulation is carried out by making the speed of this pump dependent upon the quantity of steam passing through the main turbine with which the reheating apparatus is associated. This dependence may be obtained by utilizing the pressure of the steam at some point between the main throttle valve and the condenser as a measure of the quantity of steam passing, and causing this pressure to act upon the means for driving the pump.

The desired interdependence may be obtained by taking the supply of steam for the auxiliary turbine from an appropriate stage of the main turbine. The speed of this auxiliary turbine will then rise and fall as the load on the main turbine rises and falls, and the correct relationship between these changes can be obtained by appropriate design of the blading of the auxiliary turbine and of the form of the pump, which will generally be of the centrifugal type.

The exhaust of this auxiliary turbine can either be discharged to the atmosphere or may pass through a feed heater or may go to the main condenser or be returned to a lower stage of the main turbine.

A suitable arrangement of this kind is shown in Fig. 6. *A* indicates the circulating pump, while *B* and *C* are the suction and delivery pipes, respectively. *D* is the auxiliary turbine supplied with steam through pipe *E* from the first stage of the main turbine *F*. The exhaust steam from the auxiliary turbine is led through pipe *G* at an intermediate stage of the main turbine.

Two other methods of controlling the speed of the circulating pump for the heating medium are described and illustrated in the specification. (British patent to the English Electric Co., Ltd., London, and J. P. Chittenden of Willans Works, Rugby, on "Improvements in Steam Turbine Power Plants." Date of application, Jan. 1, 1925, no. 248,154, *d*)

Wylie-Wilson Process of Boiler Blow-Off

In order to properly blow off a boiler only enough water should be let out as is necessary to keep down the concentration at the proper point, and the blow-off should be carried at the proper speed. This is not an easy matter with the ordinary system of blow-off discharging from boiler pressure to atmospheric pressure, in addition to which accidents are quite liable to occur when this is done.

To meet this condition, a closed tank suitable to take full boiler pressure is interposed in the present process between the boiler blow-off valve and the discharge valve to the sewer. The water from the boiler passes into the tank in which the proper pressure has been established by admitting steam from the boiler, and when the predetermined amount has been drawn off the discharge from the boiler automatically ceases. The water is then withdrawn from the tank at a greatly reduced pressure. Samples of water are readily obtainable from the tank for analysis, as the water is withdrawn from the tank at atmospheric or nearly atmospheric pressure. As the water flows from the boiler to the tank under gravity head pressure and automatically comes to rest when it reaches a point in the steam-pipe level with the water in the boiler, the possibility of shock is avoided. The device is manufactured by the Everlasting Valve Co., 1 Exchange Place, Jersey City, N. J. (*Power*, vol. 64, no. 10, Sept. 7, 1926, pp. 382–383, 1 fig., *g*)

RAILROAD ENGINEERING

The Locomotive of Today

In a symposium conducted by Samuel O. Dunn, Editor of *Railway Age*, at the Annual Convention of the Traveling Engineers' Association in Chicago (Sept. 14–17, 1926), the enormous difference between the locomotive of today and that of only ten years ago was pointed out. One most significant feature of the development in this line in the last ten years was the widespread employment of auxiliaries, such as superheaters, stokers, power reverse gears, brick arches, feedwater heaters, boosters, siphons, exhaust-steam injectors, and the like. Another feature was the impressive increase in power. Thus, the heaviest freight locomotive ordered in 1925 was a 2-8-8-2 type single-expansion engine for the Great Northern weighing 594,940 lb. and having a tractive power of 127,500 lb.

Larger fireboxes, better-designed grates, and higher steam pressures have helped to make the locomotive a more efficient power plant. The facts given illustrate the great development and improvement of the steam locomotive that have occurred during the last twenty years.

The effect of the improvement in locomotive design and construction in any given period can be most strikingly illustrated by showing the improvement in maximum performance. As an example of this, it was brought out in the discussion of one of the reports at the Mechanical Division convention at Atlantic City last June that a new 2-10-4 type freight locomotive built for the Texas & Pacific in 1925, when compared with an earlier design of 2-10-2 type having only slightly less weight on the driving wheels, developed 44 per cent more drawbar pull at starting, 50 per cent more at 20 m.p.h., and 50 per cent more at 40 m.p.h. An increased train speed of 33 per cent is credited to this locomotive and also a decreased fuel consumption (per thousand gross ton-miles) of 42 per cent. Other remarkable records made by the most modern power might be cited.

The heavier, more powerful, and more complicated locomotives cost more to buy. Their installation also very commonly makes necessary increased expenditure for the strengthening of bridges, maintenance of tracks, and other purposes. A different picture, however, is obtained when the matter is considered from the standpoint of the service that can be obtained.

The more powerful a locomotive is, the larger the train load it can pull. The larger train loads are, the fewer trains have to be run to handle a given traffic. The smaller the number of trains that is required to handle a given traffic, the more the traffic that can be handled before it becomes necessary to build additional main tracks.

If a locomotive is so designed, constructed, and equipped that it cannot only pull a larger train load than the locomotive it replaces, but can also make higher average speed in pulling its increased load, its value as a means of increasing the efficiency and capacity of the entire railroad is greatly enhanced. By producing more ton-miles of transportation per hour it reduces the total number of locomotives required; it postpones the time when increased investment in tracks and most other fixed properties to increase capacity will be necessary; it reduces the number of employees required, or that would be required in train service; it reduces the number of employees required in signaling and despatching trains—in fact, there is hardly any form of fixed charge or transportation expense that is not made less than it otherwise would be by locomotives that produce an increased output of ton-miles per locomotive-hour.

It is actual performance that counts. If the development of the locomotive gets ahead of the development of the means for maintaining and utilizing it, part of the benefits that might be obtained from it are not secured. A great deal has been done in this connection, but there yet remains much that can be done along this line. At the same time it is important to remember that only one-third of the locomotives now in service have been installed during the last ten years, and only about 18 per cent of them have been installed since 1920.

Nevertheless the increase in average gross ton-miles per train-hour since 1920 has been 36 per cent, while the reduction in the amount of coal consumed per 1000 gross ton-miles meantime has been about 16 per cent. There can be no doubt that the great improvement in operating results within recent years has been made possible largely by improved locomotives that have been installed within the last decade, and especially since 1920. (*Railway Age*, vol. 81, no. 12, Sept. 18, 1926, pp. 492–495, *g*)

REFRIGERATION

Follain Water-Vapor Refrigerating Machine

THIS machine was described in an abstract from a French periodical in MECHANICAL ENGINEERING, vol. 48, no. 10, Oct., 1926, p. 1060. A more detailed description has now appeared in English. (W. W. O'Mahony in *Ice and Cold Storage*, vol. 29, no. 342, Sept., 1926, pp. 227–229, 3 figs., *d*)

Tests of a Vertical Shell-and-Tube-Type Ammonia Condenser

THE condenser upon which the tests were made was 36 in. in outside diameter and contained 108 two-inch seamless steel tubes of No. 10 gage 14 ft. long. During the test the number of tubes was varied by plugging the tops with wooden plugs. The outside shell was made of hammer-welded steel pipe of $^1/_2$-in. thickness, with tube heads of 1-in. steel plate welded at the bottom and top. Every hole in the head was grooved to receive the tubes, which were rolled tightly into them and flared over at both the top and bottom.

The data are presented in a table and a number of curves, the most interesting of which are the heat-transfer curves and condensing-pressure curves, the latter as a function of various variables. The curves of heat transfer as a function of the quantity of condensing water per tube are based on the assumption of approximately constant total tonnage being handled by the condenser and a constant quantity of water. These curves indicate, at least over the range shown, that the heat transfer increases as a straight-line function. The author believes that were the condensing pressure to remain constant as the quantity of water per tube is decreased, the condenser could be shortened in length and a constant heat transfer obtained. A feature which has a decided influence upon the heat transfer of a condenser as calculated is the quantity of non-condensable gases in the system. This has not apparently been measured.

A number of curves have been plotted from the test data showing the condensing pressure as a function of the tons of refrigeration per tube at a constant quantity of water per tube.

The question as to the proper length of condensers is dependent more or less upon each particular problem. From a commercial viewpoint, however, it is desirable to have all condensers of the same length. The curves shown in Fig. 7 are interesting in that they show for the conditions outlined the temperature of the condensing water at various points in the tube as the water passes through the tubes. These readings were taken with a maximum-registering thermometer placed in a pipe which was inserted in the tube, the end of the pipe being arranged with a gasket to dam up some of the water, yet giving a free passage for the water after coming in contact with the thermometer. These tests were made before the installation of a purge drum, and are of interest in that they show where most of the work is done in the condenser.

In the discussion which followed the presentation of this paper,

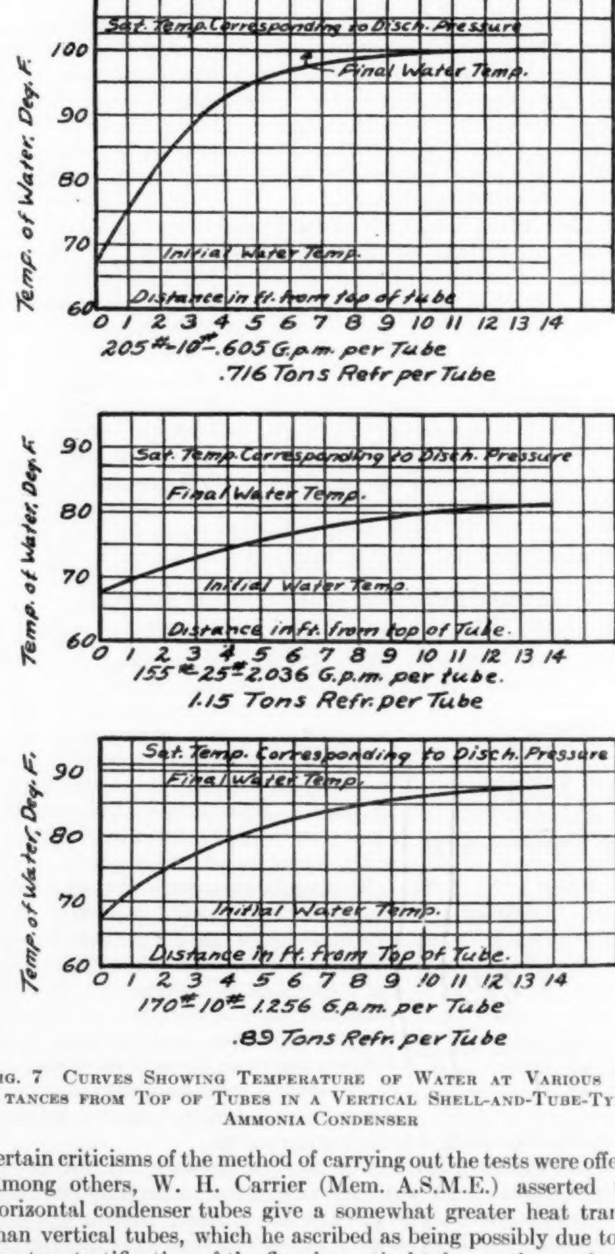


FIG. 7 CURVES SHOWING TEMPERATURE OF WATER AT VARIOUS DISTANCES FROM TOP OF TUBES IN A VERTICAL SHELL-AND-TUBE-TYPE AMMONIA CONDENSER

certain criticisms of the method of carrying out the tests were offered. Among others, W. H. Carrier (Mem. A.S.M.E.) asserted that horizontal condenser tubes give a somewhat greater heat transfer than vertical tubes, which he ascribed as being possibly due to the greater stratification of the flow in vertical tubes as the condensate flows down the tube; the condensate in horizontal tubes being broken up, part of it dropping from tube to tube and keeping the film agitated.

Heywood Cochran stated that at the University of Illinois a small vertical tubular condenser is being built that will have gas inlets at the bottom, center, and top. It will also have a large number of mercury wells at the different points reaching down into the condenser, so that a fairly thorough study can be made with dif-

ferent loads, varying amounts of water, etc. Professor Macintire will be in charge of making an elaborate study of this type of condenser. (Frank R. Zumbro, Refrigerating Engr. with Frick Co., Waynesboro, Pa., in *Refrigerating Engineering*, vol. 13, no. 2, August, 1926; original paper pp. 49–57, 13 figs., and discussion pp. 57–63 and 67, *e*)

STEAM ENGINEERING

Pass-Out Steam Engine for a Paper Mill

AT THE Otley, Yorkshire, paper mill the former slow-speed engines have been scrapped and replaced by a single reciprocating engine. So great is the reliance which the owners place on this engine that there is no standby. The engine is a standard Bellis triple-expansion set.

It differs from normal practice only in the provision of means for abstracting some of the steam between the intermediate- and low-pressure cylinders for heating purposes in the paper machines. The engine is directly connected with a direct-current dynamo of 250-kw. capacity, which is arranged between the flywheel and the outboard bearing, and beyond this there is a rope pulley for transmitting some 600 hp. to the main shafting of the pulp-beating mill. Between the generator shaft and the rope pulley there is a friction clutch, so that the electric generator can be run without the shafting if necessary. This clutch is noteworthy on account of its comparatively small overall dimensions and the great inertia of the machinery it has to set in motion (Fig. 8).

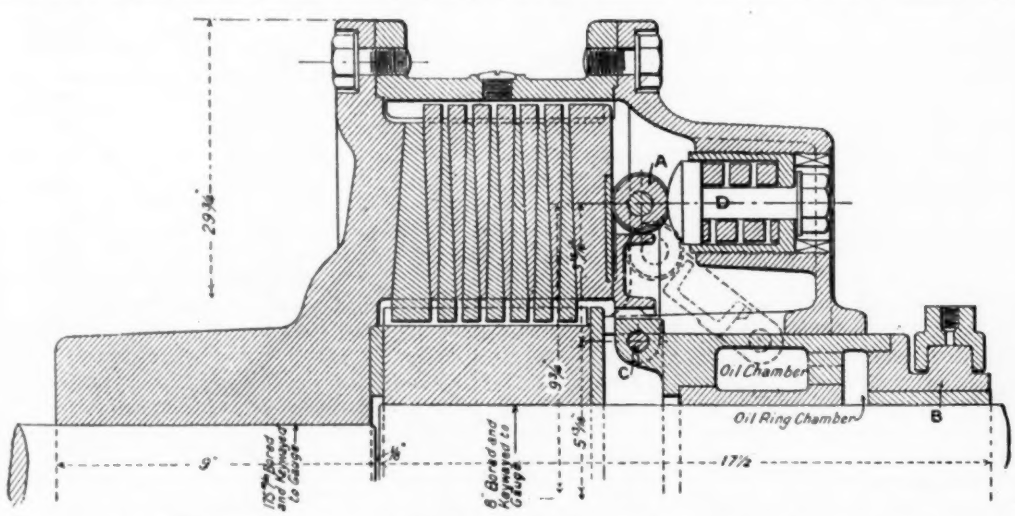


FIG. 8 FRICTION CLUTCH FOR PASS-OUT STEAM ENGINE IN AN ENGLISH PAPER MILL

As will be seen from this illustration, the clutch comprises a series of radially tapered disks mounted alternately on the driving and driven shafts. The disks are held by feathers and are pressed together to transmit the drive by means of a set of rollers *A* operated by a sliding sleeve *B*. Each of the rollers is carried by an arm pivoted to the sleeve at *C* and works in conjunction with spring buttresses *D*. The full and dotted lines in the drawing show how, by moving the sleeve inward, the rollers are forced under the curved heads of the spring buffers and the clutch plates are pressed together. The clutch plates are only 27 in. in diameter and they have to transmit some 600 hp. at a speed of 300 r.p.m., but the makers and owners tell us that they have had no trouble through the clutch slipping when engaged, or dragging when it was supposed to be free. The clutch casing, by the way, is oiltight, and is filled with lubricant.

As the engine has to deliver roughly 6000 lb. of steam per hour for process purposes, in addition to the ordinary governor and throttle valve an automatic expansion gear is fitted to vary the high-pressure cut-off, and an Arca regulator automatically maintains a pressure of 15 lb. in the heating main. The arrangement for drawing off the low-pressure steam into the heating range is shown in considerable detail in the original article. The receiver which connects the intermediate- and the low-pressure cylinders has a branch for passing off the heating steam, and immediately above this there is an apportioning valve. This valve is of the double-beat type and controls the passage of steam to the low-pressure cylinder. It is operated by a wheel over which there runs a chain connected with an Arca regulator. (This regulator was described in *The Engineer*, Mar. 27, 1925.) In tests the engine showed a very considerable saving as compared with previous machinery. (*The Engineer*, vol. 142, no. 3686, Sept. 3, 1926, pp. 257–258, 4 figs., *d*)

SPECIAL MACHINERY

Elimination of Heat Treatment of Gas Cylinders in England

ONE of the regulations recommended by the Home Office Committee of 1895 was that all gas cylinders of wrought iron or of 0.25 per cent carbon steel should be reannealed every four years. The evidence on which this decision was reached did not, however, seem to be conclusive, and the Department of Scientific and Industrial Research set up a Gas Cylinders Research Committee to make such experimental inquiry into the subject as would allow the practice of storing compressed gases to be put on a surer foundation.

The Committee decided to have definite experiments made as a preliminary to such recommendations as it might find to be desirable. As it has found reason to conclude that periodical heat treatment serves no useful purpose, it has now published its Second Report dealing with this subject, and describing the experiments on which its conclusion is based [H. M. Stationery Office, 2s. 6d. net].

The purpose of the experiments, which were carried out at the National Physical Laboratory, was, in the first instance, to determine the effects of reannealing and of renormalizing overstrained specimens of 0.25 and 0.45 per cent carbon steel. Each treatment was carried out three times, and its effects determined at each stage. The normalizing treatment consisted in raising the temperature to about 50 deg. cent. (90 deg. fahr.) above its critical range, and as soon as that temperature had been attained throughout the mass, in withdrawing the specimen from the furnace and cooling it in air, apparently protected from drafts. The annealing treatment in this first series of experiments consisted in raising the temperature of the material to 650 deg. cent. in each case, maintaining this temperature for a period of two hours, and then allowing the material to cool slowly in the furnace. This annealing treatment is similar to that employed in practice in reannealing, except that the time for which the cylinders are kept at 650 deg. cent. (1202 deg. fahr.) may be longer than two hours. The overstraining in this series of experiments was carried up to the yield point, which was very definite in all cases, and left a permanent set in 6 in. of the order of $1^1/_2$ per cent. A second set of experiments was made, in which the overstraining was carried up to a permanent set in 6 in. of the order of 6 per cent. Two series of heat-treatment experiments were made, the first in all respects similar to the previous set, and the second different only in maintaining the annealing temperature of 650 deg. cent. for 24 hr. instead of 2 hr.

The third set of experiments was directed to ascertaining whether the process of normalizing, which in the first two sets had appeared to be beneficial, was in fact necessary. The condition that, in the absence of evidence to the contrary, seemed possible was that rough handling in service, such as repeated blows on the surface of the cylinder, might cause a deterioration of the steel, particularly at the surface, and eventually lead to failure under sudden shock. Accordingly, specimen strips of steel of the same dimensions were bent over a radius of $^1/_4$ in. until surface cracks appeared. Other parts of the strips were subjected to 500 blows with a $^1/_2$-lb. hammer over an area of 1 sq. in. in the manner of light riveting, and of the

hammered strips some were annealed and some were normalized before being bent.

The first set of experiments showed in general that after reannealing the structure of the steels tended to develop carbide globules within the ferrite instead of lamellar pearlite, with a fall in ultimate strength and increased brittleness, as indicated by the Izod test. These effects became more marked after a series of overstrains and reannealings at 650 deg. cent. Renormalizing, on the other hand, seemed to do good rather than harm; in specimens that had been annealed repeatedly after overstrain, with a final normalizing treatment, it appeared that the material had been restored substantially to its original state. The second set of tests showed that annealing for long periods after substantial overstraining gave in a more pronounced form the same deleterious results as had been obtained in the first set, while a single normalizing operation after a series of severe overstrainings and subsequent annealings at 650 deg. cent. seemed to have a beneficial effect on 0.25 per cent carbon steel.

From these two sets of tests it appeared, therefore, that both immediately after manufacture and, if necessary, at a later date the best treatment for carbon-steel cylinders of similar composition to those that had been examined is normalizing. The periodical application of this process, however, would not only be inconvenient but would require care to prevent undue scaling or decarbonization, especially near the screw thread at the mouth. It was for this reason that the third set of experiments was made, in order to determine whether renormalizing was actually necessary. In the first set it had appeared that the effect of overstraining was not to embrittle but slightly to strain-harden the steel, so that it would resist the applied pressure permanently without further plastic deformation. It was thought, therefore, that no need exists for renormalizing as against the effects of excessive pressure. The third set of tests showed no tendency in the steel, whether with or without either form of heat treatment, to become brittle under hammering.

The committee is therefore of opinion that the periodical reheat treatment of cylinders that have not been obviously damaged serves no useful purpose, and should be discontinued. (*Times Trade and Engineering Supplement*, vol. 18, no. 425, Aug. 28, 1926, p. 539, *g*)

THERMODYNAMICS

Direct Measurements of the Total Heat of Steam at Pressures up to 1000 Lb. per Sq. In.

Under the auspices of the British Electrical and Allied Industries Research Association (of which the articles here abstracted constitutes Report J/T 32) experiments were undertaken on the total heat of steam. These were at first limited to a pressure and temperature of 500 lb. and 700 deg. fahr., and failed to show any deviations from the standard adiabatic except in the neighborhood of saturation. It was then decided to continue the direct measurements of the total heat to a limit of 1000 lb. (in the first instance) with a new type of boiler. This limit was reached with so little difficulty that a second boiler of the same type was installed with which a pressure of 2000 lb. should be readily attainable and a limit of 3000 lb. may be reasonably expected. Evidence has been accumulating for some time that the behavior of steam in a turbine during adiabatic expansion does not exactly conform to the laws or equations determined by static methods of experiment, especially in those cases where a partial change of state from liquid to vapor is concerned. The most familiar illustration of this is the well-established fact that steam in rapid expansion does not begin to condense until its temperature has fallen far below the saturation point corresponding to its actual pressure. According to Wilson's experiments on the expansion of air saturated with water vapor at 20 deg. cent. or 68 deg. fahr., condensation will not start, in the

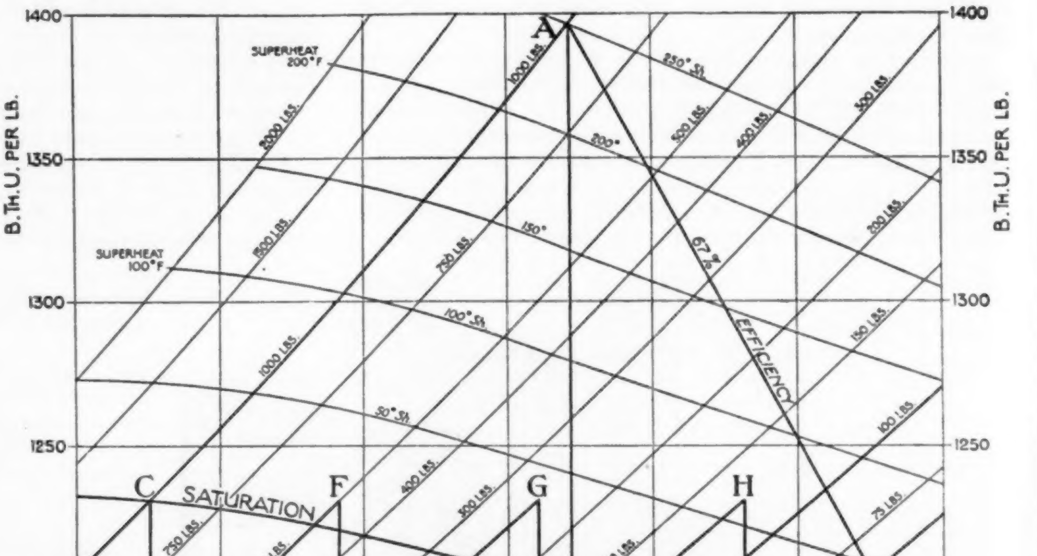


Fig. 9 Part of HΦ Diagram for Steam at High Pressures (Illustrating Supersaturation (S.S.) and Progressive Throttling)

absence of nuclei, until the temperature has fallen so low that the normal saturation pressure of the vapor is only one-eighth of that of the vapor actually present. This is more briefly expressed by saying that eightfold supersaturation is required to induce condensation in the absence of nuclei. If the same limit is assumed for a high-speed turbine, where the expansion is far more rapid than in Wilson's experiments, the drop of temperature below the saturation point corresponding to eightfold supersaturation in the neighborhood of 0.5 lb. abs. would be about 60 deg. fahr. On the ground of Wilson's experiments, the limit of eightfold supersaturation has often been adopted as the starting point of condensation at all pressures, and marked as the "8-fold S.S." limit on many diagrams. The position of this line in relation to the saturation line is shown near the bottom of the skeleton Mollier diagram in Fig. 9. It is immediately obvious that the adoption of this limit at high pressures would involve a much greater fall of temperature than is readily admissible on theoretical grounds. Thus for saturated steam at 1000 lb. the drop of temperature from *C* to *D* required to start condensation would be 300 deg. fahr., or five times as great as at 1 lb. Some authorities prefer the limit of threefold supersaturation, as indicated by the line marked "3-fold

S.S." in Fig. 9. But this leads to similar difficulties at high pressures, and gives too small a drop at low pressures. For this reason the writer has proposed a limit corresponding to 3 per cent of equivalent wetness, which agrees closely with Wilson's limit at low pressures, and has the advantage of being easy to apply in practice, with as fair a degree of probability as the case permits.

The fact that the behavior of a vapor in adiabatic expansion differs so widely from that observed under static conditions of equilibrium, renders the exact determination of the properties of saturated steam much less important in practice than it would be if the static and adiabatic limits were coincident. But since any delay in condensation necessarily involves a loss of efficiency, it is natural to take the usual saturation limit as a standard of comparison below saturation, because it represents the highest attainable performance, besides being familiar and easy to apply with the aid of well-understood methods and tables. The supersaturation limit would be quite unsuitable for this purpose on account of its uncertainty and the complexity of calculation, though it may be useful for estimating the loss of efficiency incurred in rapid expansion. On the other hand, for superheated steam the simplest form of adiabatic equation is most appropriate for use as a standard of comparison, because it has been closely verified by adiabatic methods. The properties of steam as determined by static experiments will no doubt show some deviations from the simple adiabatic in the neighborhood of saturation, but the steam in rapid expansion will have no time to take any notice of such deviations, any more than it does of the saturation limit itself. It might be thought that the adoption of the adiabatic limit above saturation and the static limit below would involve some inconsistency or discontinuity at the point where the change is made from one limit to the other. There is no risk of any error or inconsistency in the change over, provided the tables are constructed to make the pressure lines continuous on the $H\Phi$ diagram where they cross the saturation line, in which case the exact position of this line makes very little difference.

Fortunately these uncertainties in the behavior of steam at high pressures near saturation, though of great theoretical interest, are of little significance in the practical use of turbines, since it has been discovered that they can be eliminated from consideration by the employment of a sufficient degree of initial superheat. Even with initial pressures as low as 300 lb. it has been found advantageous to employ a degree of superheat as high as 300 deg. fahr., which insures that the steam can seldom reach the saturation point until the pressure has fallen to atmospheric. At higher pressures, such as 1000 lb., a much higher degree of superheat would obviously be desirable to attain a similar result; and it is commonly proposed to employ one, or even two, reheats, in spite of the excessive complication which such a proposal would entail. But even if we start with a superheat of only 250 deg. fahr. at 1000 lb. as indicated by the point A in the diagram in Fig. 9, the steam could not reach saturation in a perfectly efficient turbine until its pressure had fallen to 150 lb. In actual practice, owing to difficulties of leakage and partial admission at such high pressures, the efficiency would be unlikely to exceed 67 per cent in the first part of the expansion, as indicated by the line AB in the figure, in which case the steam would not reach saturation until its pressure had fallen as low as 30 lb. It is evident that the properties of steam near saturation at 1000 lb., as indicated by the point C on the opposite side of the figure, are quite out of the picture so far as any practical application to the turbine is concerned. So long as it was considered necessary to deduce the required value of the total heat at A from a knowledge of the latent heat of steam and the total heat of water at C, combined with measurements of the specific heat of steam at 1000 lb. over the range from C to A, the exact properties of saturated steam at C were no doubt of primary importance. But now that it has proved feasible to observe the total heat of superheated steam directly at any desired pressure or degree of superheat, we are enabled to avoid all the difficulties and uncertainties of measurement in the saturated region, which do not essentially affect the problem of the adiabatic efficiency.

The general result of this investigation up to the highest pressures so far reached, is that the simple relation between volume and total heat,

$$H - B = 13\,a/3\,P\,(V - b) \ldots\ldots\ldots\ldots\ldots [1]$$

corresponding to the standard adiabatic

$$P\,(V - b)^{1.3} = \text{constant, or } T/P^{3/13} = \text{constant} \ldots. [2]$$

may be safely employed at all such degrees of superheat as are economically possible, and affords the simplest rational method of discussing all problems of nozzle or turbine efficiency. It would appear that the deviations from these simple formulas under static conditions are much smaller than has hitherto been supposed, and are more sharply confined to the neighborhood of saturation, where they are of relatively small importance in practice. Some deviation is to be expected in this region, as previously explained, but the sharpness of the slope suggests that much of the effect is to be attributed to nuclear condensation, which is very difficult to eliminate at such high pressures. (Prof. H. L. Callendar and G. S. Callendar in *World Power*, vol. 6, no. 32, Aug., 1926, pp. 67–76, *etA*. Serial article; to be continued.)

Heat Transfer from Flowing Air to Tubes and Tube Nests

THE present investigation deals with heat transfer when the direction of the flow of air is normal to the axis of the tubes, and specifically with the determination of the coefficient of heat transfer α between hot air and tubes and tube nests through which water is flowing, under various arrangements of artificially established convection. The coefficients thus found comprise, depending upon the test arrangements, the portions of the heat transfer due to conduction, and to natural and artificial convection. It appears, however, that the amounts of heat transferred by conduction and natural convection are small in comparison with those due to the employment of artificial convection. They are so small, in fact, that they need be taken into consideration only with very low flow velocities, such as do not obtain in actual practice.

Tests were carried out on tubes from 4.6 to 28 mm. (0.181 to 1.10 in.) in diameter with air temperatures of from 12 to about 300 deg. cent. (53 to 572 deg. fahr.) and velocities of flow of from 2 to 13.4 m. (6.5 to 42.3 ft.) per sec. and the results obtained permit establishing for the magnitudes of heat transfer relationships which may be extended to other tube diameters, air temperatures, and air velocities by the application of the principle of similarity.

Control tests made on a preheater operating in a boiler plant gave results agreeing, in so far as the values of heat transfer are concerned, with the equations worked out on the basis of laboratory tests. A previous investigation made it possible to determine the distribution of temperatures over the periphery of the tubes. It was found that even with tubes of comparatively small diameter but of great wall thickness an amazingly high temperature difference (of the order of 40 deg. cent. or 72 deg. fahr.) existed between the front and rear sides when air of 180 deg. cent. (356 deg. fahr.) was blown against a tube in which water at a temperature of 15 deg. cent. (59 deg. fahr.) flowed with a velocity of, say, 7 cm. (2.7 in.) per sec.

The bulletin itself is not suitable for abstracting and only the conclusions are summarized here. The author begins by deriving an equation for the coefficient of heat transfer α between flowing air and a tube or nest of tubes lying in the stream. He obtains this from equations for the motion of elastic viscous fluids and equations for the conduction of heat in flowing gases, and by adopting Nusselt's views on similarity. The equation derived is as follows:

$$\alpha = \frac{\lambda_m}{d} C\psi\left(\frac{wd\rho_m}{\mu_m}\right) \text{ (kg-cal. per hr. per sq. m. per deg. cent.)}$$

In this equation d is the diameter of the tube in meters; w the velocity of air in meters per second; $\rho = \frac{\gamma}{g}$ = mass density of the air in $\left[\frac{\text{kg.}\,s^2}{\text{m}^4}\right]$; μ = viscosity of air in $\left[\frac{\text{kg. sec.}}{\text{m}^2}\right]$; λ = coefficient of heat conduction of air in kg-cal. per hr. per meter per deg. cent.; C = constant; ψ = a function, the value of which has to be determined experimentally.

$$\alpha = \frac{Q}{F_r(t_l - t_r)}\left[\frac{\text{kg-cal.}}{\text{h m}^2\,°\text{C}}\right] = \text{coefficient of heat transfer}$$

i.e., the amount of heat in kg-cal. which is exchanged in one hour for each square meter of the surface area of the tube when the difference between the temperatures of the tube surface and the air is 1 deg. cent. In this equation Q is the amount of heat exchanged between the air and pipe surface in kg-cal. per hour. F_r is the surface of the tube effective in heat transfer in square meters; t_l the temperature of the air, and t_r the temperature of the tube. Depending on the method of evaluating the results of the tests, α comprises also the small amounts of heat exchanged through conduction and natural convection. The temperatures t_r were average values of the various temperatures prevailing over the periphery of the tube, there being, as has been stated previously, a material difference between the temperatures not only lengthwise but around the periphery of the tube.

The tests carried out on single tubes give the following values for the coefficient of heat transfer α between flowing air and tube surface in the case of cross-flow (i.e., flow at right angles to the axis of the pipe):

$$\alpha = 0.350\,\frac{\lambda_m}{d}\left(\frac{w_m d \rho_m}{\mu_m}\right)^{0.56}$$ (kg-cal. per hr. per sq. m. per deg. cent. difference.)

in which for w_m should be substituted the average air velocity of the flow around the periphery of the tube, and for the other magnitudes with subscript m the average value within the temperature region between the temperature of the tube and the air temperature.

The bulletin also gives values for the coefficient of heat transfer in the case of nests consisting of 2, 3, 4, and 5 rows of tubes arranged in various ways.

It was found from these tests that the heat exchange between air flowing normal to tubes with internally flowing water was favorably influenced by—

(*a*) Increase of air velocity

(*b*) Staggered arrangement of tubes in nests

(*c*) Employment of tubes having a rough exterior surface and creation of strong turbulence in the air stream.

Wherever possible, tubes of small diameter should be employed, as the coefficient of heat transfer increases with a reduction of tube diameter. The foregoing holds good generally, i.e., even when instead of air another viscous and elastic medium is employed. (Data of tests carried out in the Laboratory for Technical Physics of the Munich Institute of Technology. Dr.-Ing. H. Reiher in *Forschungsarbeiten*, no. 269, 1925, 85 pp., 55 figs., 12 tables, *eA*)

TRANSPORTATION

Why People Use Buses

THE *Indian Railway Magazine* suggests that to win people back to the railways there should be less formality and more friendliness on the part of the railway staff, people the world over invariably reacting to the kind word and the pleasant smile. The trouble some times involved in purchasing a ticket at a crowded booking office, and the ordeal in getting to the platform and boarding the train, are also, in the view of our Indian contemporary, disturbing factors, while "the terror that any petty employee strikes into the heart of the illiterate passenger stands in striking contrast with the civility and hospitality that he receives at the hands of the busmen." There is the further suggestion that where railway stations are distant from town centers, train-cum-bus tickets should be issued. "If the railways could take their trains into the market place and allow passengers to board them with as little formality as they now jump on the buses, the buses would be at a hopeless disadvantage. The railways must do the best they can in this direction. Stations and trains should be made as accessible as possible from the streets. At some stations there is too much marching, countermarching, and passing of barriers. If passengers could be allowed to board short-distance trains and pay on the journey instead of having to stand in a queue at the ticket-office window and then pass a barrier, it would do much to encourage the freer use of railways." (*Railway Gazette*, vol. 45, no. 9, Aug. 27, 1926, p. 246, *g*)

VARIA

Interatomic Forces and the Strength of Metals

IT IS PROBABLY no exaggeration to say that the most important problem of scientific metallurgy awaiting solution at the present moment is the discovery of the fundamental cause of strength and elasticity in metals. Broadly regarded, the solution of this problem may be held to provide the motive, unexpressed or otherwise, of all metallurgical researches, however remote they may appear from each other. With its solution we would at least be placed in a position to determine from first principles the answers to many questions which today have to be sought, each one separately, by way of a specific investigation. Many attempts have been made to solve the problem. So far little real progress has been made, but the signs are encouraging, and it may reasonably be anticipated that not many years will pass before the accumulating knowledge of the metallurgists will provide us with a basis on which to build a sound theory explaining the fundamental cause of strength and elasticity in metals. At present the facts gathered on the subject are multitudinous and very largely uncoördinated, but with the rapid development of the method of analyzing metals by means of X-rays and with the widely significant results of experiments conducted on specimens consisting of single crystals as initiated by Professor Carpenter and Miss Elam, and being continued by many others, we should in the not distant future be able to view the problem in a new and bright light and advance a considerable way toward the elimination of guesswork and assumption from its solution. For the time being pure guessing and unsupported assumption are liberally indulged in, even to the extent of adapting well-established physical laws in order that "theory" may be made to fit with the results of practical experience. It may be laid down as axiomatic that no solution of the problem is likely to command general acceptance unless it can be squared with the established facts of physical science as a whole. Any theory which may fit the metallurgical aspects of the problem, but which fails to join up without discontinuity with our existing knowledge of non-metallurgical phenomena, should not be rashly advanced.

Investigation in many diverse fields points to matter being composed of a congeries of positive and negative electrically charged particles, or, to speak more modernly, of positive and negative particles of electricity. With such a constitution the resultant force across an interface in a body must be the resultant of a large number of attractions and a large number of repulsions. In the normal unstrained state of the body the attractions and repulsions balance. Under compression the increased repulsions outweigh the increased attractions and a force tending to make the body recover the neutral state is developed. Under extension the diminution of the repulsions proceeds more quickly than the diminution of the attractions, with the result that the net force up to a certain point is an increasing attraction, and beyond that point an attraction which decreases as the relative effect of the repulsions diminishes. It would seem an easy matter to explain strength and elasticity on this basis. Qualitatively it is so, but when we pass to a quantitative study we at once encounter difficulties of a first-class order."

The writer of the editorial from which the above is extracted does not believe that the various problems of repulsions and attractions in the atom can be solved by assigning particular values to the so-called indices. He looks for more light on the subject from such work as Professor Carpenter's experiments on single crystals of aluminum, but even then there is still a large amount of unexplained matter, and while progress has been made, such calculations and theories as have been worked out apply only to single-crystal specimens concerning the curious and unusual properties of which we are only beginning to gain knowledge. "When the fundamental principles governing the strength and elasticity of single-crystal specimens have been worked out and explained," the writer concludes, "it will still remain to undertake the probably more formidable cases of ordinary polycrystalline metals. Then and not till then, will we be able to apply the knowledge gained to practical ends." (Editorial in *The Engineer*, vol. 142, no. 3688, Sept. 17, 1926, pp. 309–310)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Proposed Standard for Spur-Gear Tooth Form

IN JUNE, 1926, the American Engineering Standards Committee authorized the organization of a Sectional Committee on the Standardization of Gears. This Sectional Committee is sponsored by the American Gear Manufacturers' Association and The American Society of Mechanical Engineers.

The Sectional Committee consists of 30 representatives of 14 national organizations and is composed of manufacturers, consumers, and general interests who organized Sub-Committees to standardize gear nomenclature, spur-gear tooth form, helical, worm, and bevel gears, as well as materials used in manufacturing gears, their inspection, and horsepower rating.

This first Sub-Committee to complete a draft standard was that on Spur-Gear Tooth Form, which is headed by Mr. Henry J. Eberhardt. This Sub-Committee No. 4 was organized in February,

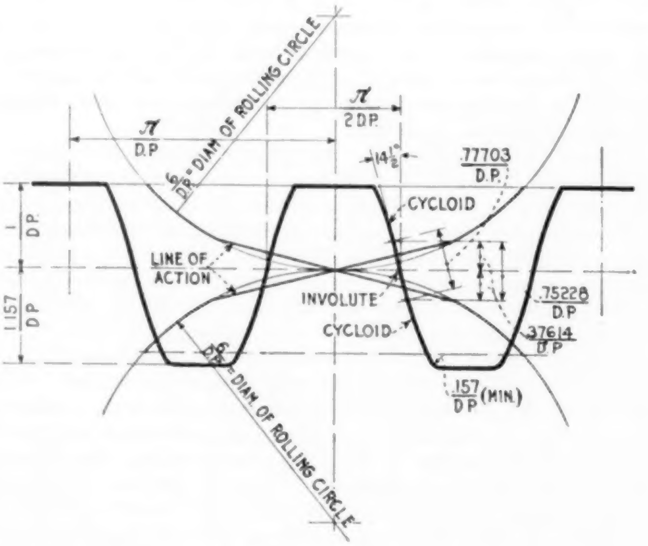


FIG. 1 BASIC RACK FOR 14½-DEG. COMPOSITE SYSTEM (FULL-DEPTH TOOTH)

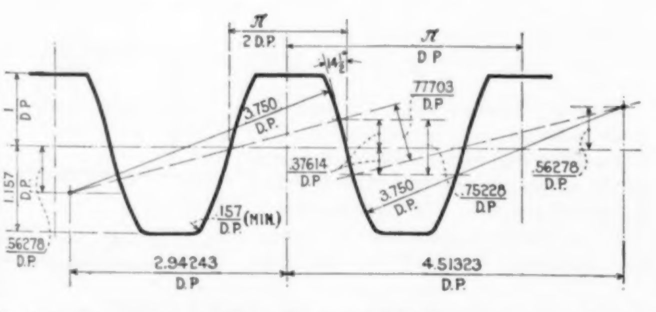
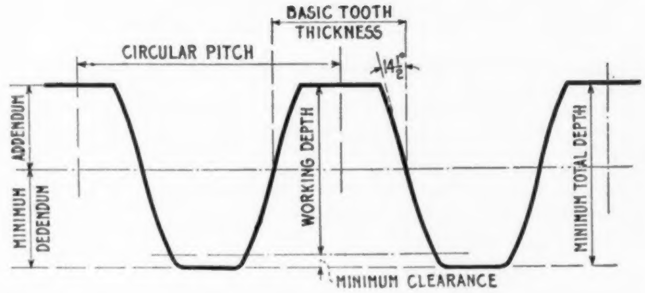


FIG. 2 APPROXIMATION TO BASIC RACK FOR 14½-DEG. COMPOSITE SYSTEM (FULL-DEPTH TOOTH)

1924, to study all the available information and recommend a group of standards. During frequent meetings held at different points throughout the country several drafts of its first report were formulated and discussed. The proposed standard printed herewith represents present practice for the 14½-deg. full-depth and the 20-deg. stub tooth, and has the approval of the Sectional Committee.

Now that the Sectional Committee has approved this proposed standard, it is before the two sponsor bodies for approval and transmission to the American Engineering Standard Committee. Copies of the proposed standard in page-proof form are now available to those especially interested and may be procured by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.



FULL-DEPTH TOOTH PROPORTIONS FOR 14½-DEG. COMPOSITE SYSTEM FOR SPUR GEARS

1 The use of both Diametral and Circular Pitches[1]

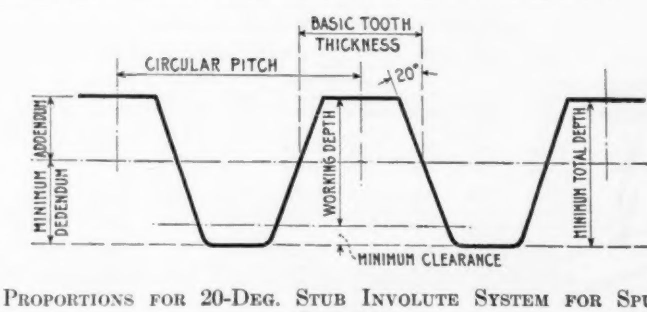
	In Terms of— Diametral Pitch	Circular Pitch
2 Addendum	$= \frac{1''}{\text{D. P.}}$	$0.3183 \times$ C. P.
3 Minimum Dedendum[2]	$= \frac{1.157''}{\text{D. P.}}$	$0.3683 \times$ C. P.
4 Working Depth	$= \frac{2''}{\text{D. P.}}$	$0.6366 \times$ C. P.
5 Minimum Total Depth[2]	$= \frac{2.157''}{\text{D. P}}$	$0.6866 \times$ C. P.
6 Pitch Diameter	$= \frac{N}{\text{D. P.}}$	$0.3183 \times N \times$ C. P.
7 Outside Diameter	$= \frac{N + 2}{\text{D. P.}}$	$0.3183 \times (N + 2) \times$ C. P.
8 Basic Tooth Thickness on Pitch Line	$= \frac{1.5708''}{\text{D. P.}}$	$0.5 \times$ C. P.
9 Minimum Clearance[2,3]	$= \frac{0.157''}{\text{D. P.}}$	$0.05 \times$ C. P.

N = Number of Teeth.

[1] Diametral Pitch used up to 1 D. P., inclusive. Circular Pitch used for 3-in. C. P. and over.

[2] A suitable working tolerance should be considered in connection with all minimum recommendations.

[3] Minimum Clearance refers to the clearance between the top of the gear tooth and the bottom of the mating gear space, and is specified as "minimum" so as to allow for necessary cutter clearance for all methods of producing gears. At the present time this value cannot be standardized.



PROPORTIONS FOR 20-DEG. STUB INVOLUTE SYSTEM FOR SPUR GEARS[2,3]

1 The use of both Diametral and Circular Pitches[1]

	In Terms of— Diametral Pitch	Circular Pitch
2 Addendum	$= \frac{0.8''}{\text{D. P.}}$	$0.2546 \times$ C. P.
3 Minimum Dedendum	$= \frac{1''}{\text{D. P.}}$	$0.3183 \times$ C. P.
4 Working Depth	$= \frac{1.6''}{\text{D. P.}}$	$0.5092 \times$ C. P.
5 Minimum Total Depth	$= \frac{1.8''}{\text{D. P.}}$	$0.5729 \times$ C. P.
6 Pitch Diameter	$= \frac{N}{\text{D. P.}}$	$0.3183 \times N \times$ C. P.

7 Outside Diameter $= \dfrac{N + 1.6''}{D.\ P.}$ P. D. + (2 Addendums)

N = Number of Teeth. P. D. = Pitch Diameter.

[1] Diametral Pitch used up to 1 D. P. inclusive. Circular Pitch used for 3-in. C. P. and over.

[2] These proportions are identical with those of the recommended practice for herringbone gears.

[3] A minimum root clearance of 0.2 inch ÷ Diametral Pitch is recommended for new cutters and gears. There is correct tooth action, however, between gears cut to this standard system and those cut to the Nuttall system, the only dimension affected being the clearance. Where the proposed gear tooth meshes with a Nuttall gear space there is a clearance of 0.1425 inch ÷ Diametral Pitch, and where the Nuttall tooth runs with the proposed gear space there is a clearance of 0.2146 inch ÷ Diametral Pitch.

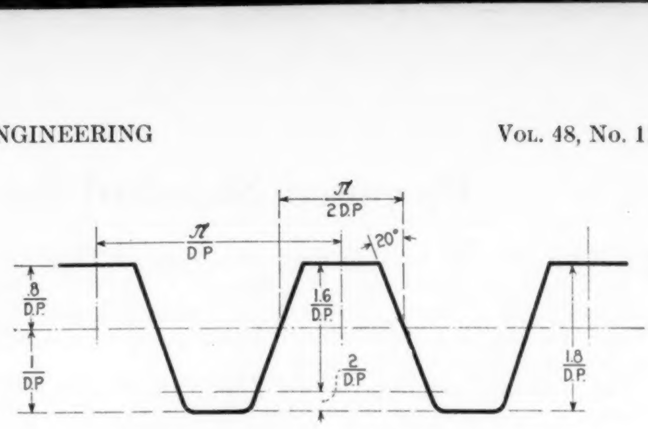


Fig. 3 Basic Rack for 20-Deg. Stub Involute System for Spur Gears

T-Slots, Their Bolts, Nuts, and Cutters

Introductory Notes

Historical Background. Advocates of standardization for machine parts, especially work- and tool-holding elements, have repeatedly urged the standardization of T-slots as one of the first and most important steps which can be taken to bring about interchangeability in the machine-tool industry.

As far back as 1889, James W. See, famous as the author of Chordal's Letters, presented a paper before the A.S.M.E. on Standards, in which he definitely included T-slots among the subjects which he believed were important to be standardized. In 1916 Carl G. Barth, in a paper before the same Society, entitled Standardization of Machine Tools, again strongly urged the standardization of T-slots. In another paper by Fred. H. Colvin and K. H. Condit, on the same subject and before the same Society, in 1922, such standardization was still further urged. During the years of this discussion specific recommendations were made by many, including those by H. Cadwallader, Jr., in an article entitled Standardization of T-Slots, published in *Machinery*, September, 1922. The National Machine Tool Builders' Association also urged such standardization in 1922.

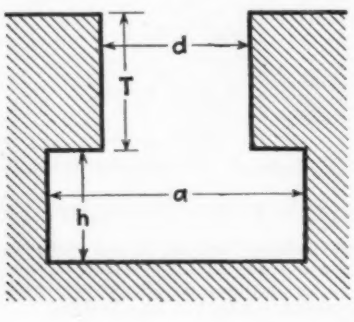


TABLE 1 T-SLOTS—SEE SKETCH ABOVE

Diameter of T-bolt[2,3]	Width of throat[1,2,3] (*d*)	Depth of throat (*T*) Maximum	Depth of throat (*T*) Minimum	Head-Space Dimensions and Tolerances — Width (*a*) Maximum (basic)	Width (*a*) Tolerance (minus)	Width (*a*) Maximum	Depth (*h*) Maximum (basic)	Depth (*h*) Tolerance (minus)	Depth (*h*) Minimum
1/4	9/32	3/8	1/8	9/16	0.063	1/2	15/64	0.031	13/64
5/16	11/32	7/16	5/32	21/32	0.063	19/32	17/64	0.031	15/64
3/8	7/16	9/16	7/32	25/32	0.063	23/32	21/64	0.031	19/64
1/2	9/16	11/16	5/16	31/32	0.063	29/32	25/64	0.031	23/64
5/8	11/16	7/8	7/16	1 1/4	0.063	1 3/16	31/64	0.031	29/64
3/4	13/16	1 1/16	9/16	1 15/32	0.094	1 3/8	5/8	0.031	19/32
1	1 1/16	1 1/4	3/4	1 27/32	0.094	1 3/4	53/64	0.047	25/32
1 1/4	1 5/16	1 9/16	1	2 7/32	0.094	2 1/8	1 3/32	0.063	1 1/32
1 1/2	1 9/16	1 15/16	1 1/4	2 21/32	0.094	2 9/16	1 11/32	0.063	1 9/32

All dimensions in inches.

[1] A tolerance of minus 0.001 is allowed for "width of throat" when tongues or other parts must fit.

[2] In addition to the "width of throat" given above, a secondary standard is recognized, having the "width of throat" the same as the nominal diameter of the T-bolt. This is to provide for the use during the transition period of this standard on many machine tools where it is already established.

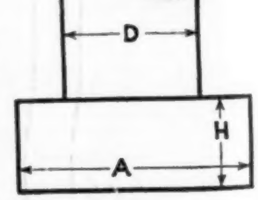
[3] "Width of tongue" to be used with the above T-slots will be found in Table 5.

Action in this matter was finally crystallized in the appointment of a Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements under the auspices of the A.E.S.C., with the National Machine Tool Builders' Association, the Society of Automotive Engineers, and the A.S.M.E. as joint sponsors. The first Sub-Committee organized under this General Committee was that on T-slots. This Committee held a meeting for organization early in 1924. A Working Committee was appointed which has held many meetings and has conducted such lines of research as it felt could give a practical basis for the standards recommended. A review of this research work and of the varied practice of many manufacturers, together with T-slot standardization abroad, forms the subject of a paper prepared and presented by Luther D. Burlingame before the Providence Regional Meeting of the A.S.M.E. in May, 1926.

Reason for Standardization. An important reason for the standardization of T-slots is that the product of one manufacturer may interchange with that of another, so that all fixtures, attachments, bolts, and other accessories may be readily used interchangeably on machines of different makes. To bring this about it is necessary that the tongues of fixtures, the heads of the bolts, or the T-nuts, if used, shall be of such proportions as to provide the desired fits and give the necessary clearances when engaging the T-slot.

Existing Standards and Tendencies. Many manufacturers have standardized T-slots for their own lines of production. This has led to the development of individual and varying standards. Some of these standards have been based on the strength of ordinary gray iron in the castings of the tables or other places where T-slots are located, and of comparatively low-grade steel for the bolts or studs. Others have been based on the use of "hard" cast iron or semi-steel for the tables, and the use of bolts or studs with high tensile strength.

Foreign standardization has tended toward the use of deeper slots and thicker heads than in the case of American practice. There seems to be a growing demand for greater clearance to provide for oil and chip space and to insure that the body of the bolts will slide freely in the slots, and many have brought this about by using a slightly wider throat as well as by increasing the clearance for the head space.



Basis of Proposed Plan. Taking all these matters into consideration, this Committee has formulated a standard which agrees closely with the average American practice. It recommends a width of throat greater than the nominal diameter of the bolt, with the

TABLE 2 T-BOLTS—SEE SKETCH ABOVE

Diameter of T-bolt[1,2] (*D*)	Threads per inch[1]	Bolt-Head Dimensions and Tolerances — Width across flats (*A*) Maximum (basic)	Width across flats (*A*) Tolerance (minus)	Width across flats (*A*) Minimum	Width across corners	Height (*H*) Maximum (basic)	Height (*H*) Tolerance (minus)	Height (*H*) Minimum
1/4	20	15/32	0.031	7/16	0.663	5/32	0.016	9/64
5/16	18	9/16	0.031	17/32	0.796	3/16	0.016	11/64
3/8	16	11/16	0.031	21/32	0.972	1/4	0.016	15/64
1/2	13	7/8	0.031	27/32	1.238	5/16	0.016	19/64
5/8	11	1 1/8	0.031	1 3/32	1.591	13/32	0.016	25/64
3/4	10	1 5/16	0.031	1 9/32	1.856	17/32	0.031	1/2
1	8	1 11/16	0.031	1 21/32	2.387	11/16	0.031	21/32
1 1/4	7	2 1/16	0.031	2 1/32	2.917	15/16	0.031	29/32
1 1/2	6	2 1/2	0.031	2 15/32	3.536	1 3/16	0.031	1 5/32

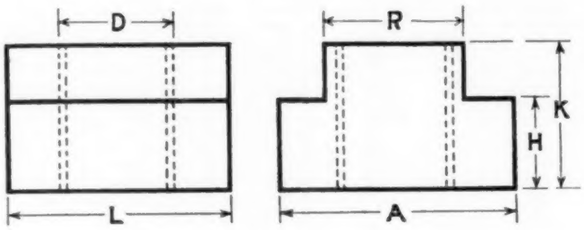
All dimensions in inches.

[1] Tolerances for diameters of bolts or studs and for threads are in accordance with the American (National) Standard Screw Threads, Coarse-Thread series, Medium Fit (Class 3) published by The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y. If a free or close-fit thread is desired the tolerances given in the American Standard Screw Threads for either of these classes of fit shall be followed.

[2] T-slots to be used with these bolts will be found in Table 1.

thought that this should eventually become the sole standard, but temporarily provides for an alternative standard having the throat width equal to the nominal diameter of the bolt so that during the transition period of this standard may be used in many machine tools where it is already established, agreeing in this respect with British practice. Provision is made in this report for finished T-slots and bolts only.

T-nuts are sometimes useful where the ends of the T-slot are obstructed so that the bolt cannot be slipped in and out. The standard recommended calls for the use of a stud of a smaller size than the T-bolt for the corresponding slot, thus insuring the full strength of the nut.



The T-slot cutters listed do not agree with the sizes of such cutters which have been on the market for many years because of the provision here made for greater head space. However, it will be found that by the simplified-practice recommendation of the Department of Commerce on milling cutters the old lines of cutters have been withdrawn from the market in order to reduce the varieties carried in stock. It should accordingly be possible to secure cutters of the new dimensions as conveniently and at the same price as those which were formerly listed.

It is recommended that T-bolts, nuts, and slots be known by the diameter of the bolt, even though in actual measurement a 1/2-in. T-slot, for example, would measure 9/16 in. in width of throat. No definite provision has been made for the chamfering of corners, the amount of this chamfering or rounding being left to the discretion of each manufacturer to fit his particular needs. The tolerances for widths of tongues are left to the discretion of each manufacturer to suit his requirements; the classes of fits given in the report on Tolerances, Allowances, and Gages for Metal Fits published by The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., are recommended by the Committee.

TABLE 3 T-NUTS—SEE SKETCH ABOVE

Tap for stud[3] (D)		Width of throat T-slot	Width of tongue (R)			Width of nut[2] (A)			Height of nut[2] (H)			Total thickness, including tongue (K)	Length of nut[1] (L)
Diameter	Threads per inch		Maximum (basic)	Tolerance (minus)	Minimum	Maximum (basic)	Tolerance (minus)	Minimum	Maximum (basic)	Tolerance (minus)	Minimum		
1/4	20	11/32	0.330	0.010	0.320	9/16	0.031	17/32	3/16	0.016	11/64	9/32	9/16
5/16	18	7/16	0.418	0.010	0.408	11/16	0.031	21/32	1/4	0.016	15/64	3/8	11/16
3/8	16	9/16	0.543	0.010	0.533	7/8	0.031	27/32	5/16	0.016	19/64	17/32	7/8
1/2	13	11/16	0.668	0.010	0.658	1 1/8	0.031	1 3/32	13/32	0.016	25/64	5/8	1 1/8
5/8	11	13/16	0.783	0.010	0.773	1 5/16	0.031	1 9/32	17/32	0.031	1/2	25/32	1 5/16
3/4	10	1 1/16	1.033	0.015	1.018	1 11/16	0.031	1 21/32	11/16	0.031	21/32	1	1 11/16
1	8	1 5/16	1.273	0.015	1.258	2 1/16	0.031	2 1/32	15/16	0.031	29/32	1 5/16	2 1/16
1 1/4	7	1 9/16	1.523	0.015	1.508	2 1/2	0.031	2 15/32	1 3/16	0.031	1 5/32	1 5/8	2 1/2

All dimensions in inches.

[1] There are no tolerances given for the "total thickness" or "length of nut" as they need not be held to close limits.
[2] T-slot dimensions to fit the above T-nuts will be found in Table 1.
[3] When T-nuts are used, stud (D) is made smaller than the corresponding T-bolt, to insure the full strength of T-nut.

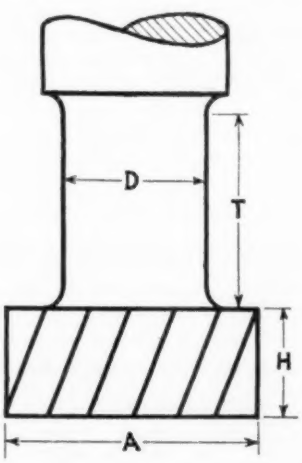


TABLE 4 T-SLOT CUTTERS—SEE SKETCH ABOVE

Width of throat[1,2]		Thickness of cutter (H)		Diameter of cutters (A)		Diameter of neck[2] (D)	Length of neck[2] (T)
Standard	Nominal bolt size	Maximum	Minimum (worn)	Maximum	Minimum (worn)		
9/32	1/4	15/64	13/64	9/16	1/2	17/64	3/8
11/32	5/16	17/64	15/64	21/32	19/32	21/64	7/16
7/16	3/8	21/64	19/64	25/32	23/32	13/32	9/16
9/16	1/2	25/64	23/64	31/32	29/32	17/32	11/16
11/16	5/8	31/64	29/64	1 1/4	1 3/16	21/32	7/8
13/16	3/4	5/8	19/32	1 15/32	1 3/8	25/32	1 1/16
1 1/16	1	53/64	25/32	1 27/32	1 3/4	1 1/32	1 1/4
1 5/16	1 1/4	1 3/32	1 1/32	2 7/32	2 1/8	1 9/32	1 9/16
1 9/16	1 1/2	1 11/32	1 9/32	2 21/32	2 9/16	1 17/32	1 15/16

All dimensions in inches.

[1] The "width of throat" given in the above table corresponds to that given in Table 1 on T-slots.

[2] In addition to the "width of throat" given above, a secondary standard is recognized, having the "width of throat" the same as the nominal diameter of the T-bolt. This is to provide for the use, during the transition period, of this standard on many machine tools where it is already established. If the narrower throat is used, the diameter of neck D should be reduced accordingly.

In accordance with the preceding study the standards listed in the tables herein are recommended for adoption.

Now that the Sectional Committee has approved this proposed standard, it is before the two sponsor bodies for approval and transmission to the American Engineering Standards Committee. Copies of the proposed standard in page-proof form are now available to those especially interested and may be procured by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Appendix

Inserted and Reversible Tongues and Tongue Seats

To provide, during a transitional period, for the interchange of attachments fitted to T-slots having the throat in some cases equal to and in other cases wider than the nominal size of T-bolt referred to in the notes of Tables 2, 4, and 5, special tongues can be provided, Table 7 showing reversible tongues for slots of two widths using the same size T-bolt.

Table 8 provides for a series of tongues such that a pair of tongues will adapt fixtures to machines of different sizes, and using a different size of T-bolt, and will also adapt these fixtures to be used on different machines having two widths of slots for the same size of T-bolt.

If smaller or larger sizes are required the geometric progression of the sizes listed herein should be followed.

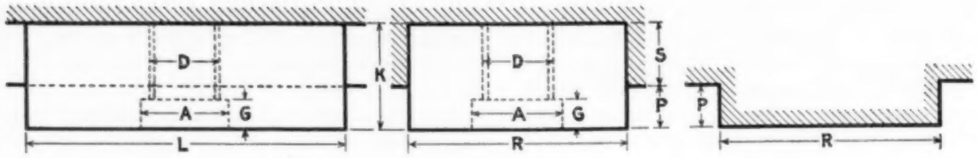


TABLE 5 INSERTED OR SOLID PLAIN TONGUES AND TONGUE SEATS FOR SINGLE-WIDTH T-SLOTS

Diameter of T-bolt[1]	Tongue Dimensions: Width[1,3] (R)	Tongue Dimensions: Length[2] (L)	Tongue Dimensions: Projection (P)	Depth of seat (S)	Total thickness (K)	Screw Dimensions: Diameter of screw (D)	Screw Dimensions: Number of screw	Screw Dimensions: Threads per inch	Screw Dimensions: Diameter of head (A)	Screw Dimensions: Thickness of head (G)
1/4	9/32	3/8	3/32	1/8	7/32	0.125	5	40	0.196	0.081
5/16	11/32	15/32	1/8	5/32	9/32	0.164	8	32	0.260	0.107
3/8	7/16	9/16	1/8	3/16	5/16	0.190	10	24	0.303	0.124
1/2	9/16	3/4	1/8	7/32	11/32	1/4	..	20	0.375	0.130
5/8	11/16	15/16	1/8	1/4	3/8	1/4	..	20	0.375	0.130
3/4	13/16	1 1/8	5/32	9/32	7/16	5/16	..	18	0.438	0.150
1	1 1/16	1 1/2	7/32	11/32	9/16	3/8	..	16	0.500	0.170
1 1/4	1 5/16	1 7/8	1/4	3/8	5/8	3/8	..	16	0.550	0.170
1 1/2	1 9/16	2 1/4	5/16	7/16	3/4	1/2	..	13	0.625	0.210

All dimensions in inches.

[1] In addition to the "width of tongue" given in the above table, a secondary standard is recommended having a width the same as the "nominal diameter of bolt." This is to provide for the use, during the transition period, of this standard on many machine tools where it is already established.

[2] The "length of tongue" can be varied to suit conditions.

[3] The "width of tongue" in the above table corresponds to the "width of throat" for T-slots in Table 1.

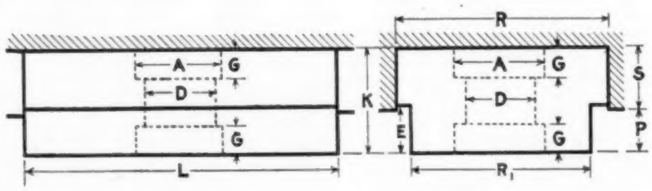


TABLE 6 REVERSIBLE TONGUES AND TONGUE SEATS FOR SLOTS FOR TWO SIZES OF T-BOLTS

Diameter of T-bolt: Small	Diameter of T-bolt: Large	Tongue Dimensions: Width[1,3] (R_1)	Tongue Dimensions: Width[1,3] (R)	Tongue Dimensions: Length[2] (L)	Tongue Dimensions: Projection (P)	Depth of seat (S)	Total thickness, including tongue (K)	Height of shoulder (E)	Screw Dimensions: Diameter of screw (D)	Screw Dimensions: Number of screw	Screw Dimensions: Threads per inch	Screw Dimensions: Diameter of head (A)	Screw Dimensions: Thickness of head (G)
1/4	5/16	9/32	11/32	15/32	1/8	5/32	/32	1/8	0.164	8	32	0.260	0.107
5/16	3/8	11/32	7/16	9/16	1/8	3/16	5/16	9/64	0.190	10	24	0.303	0.124
3/8	1/2	7/16	9/16	3/4	1/8	7/32	11/32	5/32	0.250	..	20	0.375	0.130
1/2	5/8	9/16	11/16	15/16	1/8	1/4	3/8	5/32	1/4	..	20	0.375	0.130
5/8	3/4	11/16	13/16	1 1/8	5/32	9/32	7/16	3/16	5/16	..	18	0.438	0.150
3/4	1	13/16	1 1/16	1 1/2	7/32	11/32	9/16	1/4	3/8	..	16	0.500	0.170
1	1 1/4	1 1/16	1 5/16	1 7/8	1/4	3/8	5/8	9/32	3/8	..	16	0.500	0.170
1 1/4	1 1/2	1 5/16	1 9/16	2 1/4	5/16	7/16	3/4	11/32	1/2	..	13	0.625	0.210

All dimensions in inches.

[1] In addition to the "width of tongue" given in the above table, a secondary standard is recommended having a width the same as the "nominal diameter of bolt." This is to provide for the use, during the transition period, of this standard on many machine tools where it is already established.

[2] The "length of tongue" can be varied to suit conditions.

[3] The "width of tongue" in the above table corresponds to the "width of throat" for T-slots in Table 1.

TABLE 7 REVERSIBLE TONGUES AND TONGUE SEATS FOR T-SLOTS OF TWO WIDTHS USING THE SAME SIZE T-BOLT

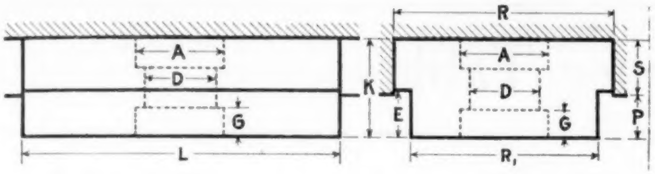
Diameter of T-bolt	Tongue Dimensions: Width[1] (R_1)	Tongue Dimensions: Width[1] (R)	Tongue Dimensions: Length[2] (L)	Tongue Dimensions: Projection (P)	Depth of seat (S)	Total thickness, including tongue (K)	Height of shoulder (E)	Screw Dimensions: Diameter of screw (D)	Screw Dimensions: Number of screw	Screw Dimensions: Threads per inch	Screw Dimensions: Diam. of head (A)	Screw Dimensions: Thickness of head (G)
1/4	1/4	9/32	3/8	3/32	1/8	7/32	3/32	0.125	5	40	0.196	0.081
5/16	5/16	11/32	15/32	1/8	5/32	9/32	1/8	0.164	8	32	0.260	0.107
3/8	3/8	7/16	9/16	1/8	3/16	5/16	9/64	0.190	10	24	0.303	0.124
1/2	1/2	9/16	3/	1/8	7/32	11/32	5/32	1/4	..	20	0.375	0.130
5/8	5/8	11/16	15/16	1/8	1/4	3/8	5/32	1/4	..	20	0.375	0.130
3/4	3/4	13/16	1 1/8	5/32	9/32	7/16	3/16	5/16	..	18	0.438	0.150
1	1	1 1/16	1 1/2	7/32	11/32	9/16	1/4	3/8	..	16	0.500	0.170
1 1/4	1 1/4	1 5/16	1 7/8	1/4	3/8	5/8	9/32	3/8	..	16	0.400	0.170
1 1/2	1 1/2	1 9/16	2 1/4	5/16	7/16	3/4	11/32	1/2	..	13	0.625	0.210

All dimensions in inches.

[1] The "width of tongue" in the above table includes the recognized secondary standard having widths (R_1) the same as the diameter of the corresponding T-bolt. This is to provide for the use, during the transition period of this standard on many machine tools where it is already established.

[2] The "length of tongue" can be varied to suit conditions.

Note:—T-slot dimensions will be found in Table 1.



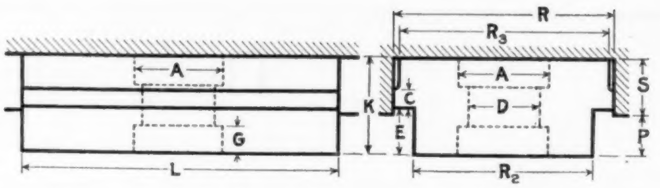


TABLE 8 COMBINATION REVERSIBLE TONGUES FOR T-SLOTS WITH TWO SIZES OF T-BOLTS AND FOR TWO WIDTHS OF T-SLOTS WITH THE SAME SIZE T-BOLT

Diameter of T-bolt[1] Small	Diameter of T-bolt[1] Large	Tongue Dimensions — Width[1] (R_1)	Width (R)	Width (R_3)	Width (R_2)	Length[2] (L)	Projection (P)	Depth of seat (S)	Total thickness, including tongue (K)	Height of shoulder (E)	Thickness of land (C)	Screw Dimensions — Diameter of screw (D)	Number of screw	Threads per inch	Diam. of head (A)	Thickness of head (G)
1/4	5/16	9/32	11/32	5/16	1/4	15/32	1/8	3/16	5/16	1/8	1/16	0.164	8	32	0.260	0.107
5/16	3/8	11/32	7/16	3/8	5/16	9/16	1/8	7/32	11/32	9/64	1/16	0.190	10	24	0.303	0.124
3/8	1/2	7/16	9/16	1/2	3/8	3/4	1/8	1/4	3/8	5/32	1/16	0.150	..	20	0.375	0.130
1/2	5/8	9/16	11/16	5/8	1/2	15/16	1/8	9/32	13/32	5/32	3/32	1/4	..	20	0.375	0.130
5/8	3/4	11/16	13/16	3/4	5/8	1 1/8	5/32	5/16	15/32	3/16	3/32	5/16	..	18	0.438	0.150
3/4	1	13/16	1 1/16	1	3/4	1 1/2	7/32	3/8	19/32	1/4	3/32	3/8	..	16	0.500	0.170
1	1 1/4	1 1/16	1 5/16	1 1/4	1	1 7/8	1/4	7/16	11/16	9/32	1/8	3/8	..	16	0.500	0.170
1 1/4	1 1/2	1 5/16	1 9/16	1 1/2	1 1/4	2 1/4	5/16	1/2	13/16	11/32	1/8	1/2	..	13	0.625	0.210

All dimensions in inches.

[1] The above table provides for a series of tongues so that a pair of tongues can be used with fixtures to machines of different sizes, using a different size T-bolt, and can also be used with fixtures on different machines having two widths of T-slots for the same size T-bolt.

[2] The "length of tongue" can be varied to suit conditions.

Note:—T-slot dimensions will be found in Table 1.

A Precision Method of Grinding for Quantity Production

"GRINDING," like many another English word, has more than one signification. To the miller it means making flour of grain. To power and metallurgical engineers it means reducing coal or ore to powder as a step in a process. To machinists it meant not so many years ago giving metal parts a refined finish by removing a little surface metal with a small thin abrasive wheel in a light machine.

In 1886, Charles H. Norton, born at Plainville, Conn., in 1851, began putting a new meaning into "grinding." Progress was slow. In 1895, Niagara, harnessed, began to supply electric current in unprecedented quantity at low price. About this time, Charles B. Jacobs invented a new abrasive, known by the trademark "Alundum." Soon Aldus C. Higgins followed with the water-cooled electric furnace for producing alundum abrasive in quantity, in the works of a company bearing the name of a Norton of another tribe. Norton, C. H., now had a strong, effective cutting medium for his grinding machines.

Norton was trained at the Seth Thomas Clock Works in making machines for indicating the passage of time. He was impressed deeply with the value and the never failing exactness of time. Later, he noted the great amount of time and highly paid labor then required for precision grinding. Realizing more and more the usefulness of precision grinding in modern machine production, he set out to reduce its cost. About that time, new special steels were making feasible very deep cuts with metal-working tools and were absorbing interest generally. Norton, however, appears to have been first to perceive that the electric furnace abrasive wheel, mounted in a heavy machine, might remove metal in small particles as rapidly as the special-steel cutting tools. This conception started him on his experimentation.

At first, "practical" machinists thought Norton's ideas very impractical. Fortunately, however, there were enough courage and money to back his investigations and demonstrations. During the past two decades, a remarkable evolution has been wrought, a new mechanical process has been brought into wide use.

Twenty-five years ago the grinding machine was a light, low-powered tool, polishing surfaces and occasionally doing accurate sizing to a limit of one-thousandth of an inch, at great cost. Today, a heavy, high-powered production tool with a precision of one four-thousandth of an inch in commercial manufacturing, it has become a big factor in low-cost and high-rate production of automobiles, locomotives, machine tools, cash registers, linotypes, monotypes, adding machines, typewriters, agricultural machinery, machine tools, armament and many other metal objects.

Norton's fundamental idea was that a modern abrasive wheel set in a sturdy machine and driven by a lot of power could cut metal rapidly, accurately and cheaply in spite of high first cost for equipment. Old grinding machines used a fraction of a horsepower. He proposed applying at least 15 horsepower in each machine. The old wheels removed about one-sixteenth of a cubic inch of metal per minute. Grinding machines now remove from two to six cubic inches and in rare operations as much as twelve cubic inches each minute. Frequently, when cutting as much as three to four cubic inches of metal in a minute, grinding machines leave the work sufficiently accurate and well finished to need no further refinement. From being a method of securing refinement at great cost, grinding has become one of the cheapest methods of production for cylindrical objects of metal with finished surfaces. Flat surfaces also can be produced very accurately.

Novel features were introduced for getting great accuracy without the highly skilled machinist. Mechanics of ordinary training can obtain the desired results. Modern quantity production demands interchangeability of parts. All parts must be made so accurately as to size and shape that any of them can be used without selection in putting the mechanisms together. The new grinding machines made it possible to secure exact size on repetitive work in unlimited quantities.

The old conception of precision and delicate adjustment was embodied in light, small, beautifully made mechanisms. Norton made massive machines with heavy operating parts capable of being moved a distance so small that a line of that width could not be seen with the naked eye. That the movement can be made repeatedly with absolute dependability has often been proved by making four adjustments of twenty-five one-hundred-thousandths of an inch, always arriving exactly on the test line. The paper on which this narrative is printed is about five one-thousandths of an inch thick. Imagine it split twenty times and you will get some conception of the precision with which these modern grinding machines can cut metal.

By combining massiveness and large power with great precision and utilizing the superior new abrasives, Norton developed a new art of cutting metal which has contributed largely to present-day economy and efficiency of many machines in daily use on farm, highway and railroad, and in factory, office and home. (Contributed on request by Aldus C. Higgins, Mem. A.S.M.E., for *Research Narratives*, vol. 6, no. 9, Sept. 1, 1926.)

Experiments with crops in the vicinity of wireless aerials near Potsdam have shown that one field with aerials, notwithstanding poor soil, has produced rich crops of wheat rye, potatoes and other vegetables whereas another field, without aerials, remains unproductive.—*Engineering*, Oct. 1, 1925, p. 261.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work, are:

ARCHIBALD BLACK, Aeronautic Division
H. W. BROOKS, Fuels Division
R. L. DAUGHERTY Hydraulic Division
W. F. DIXON, Machine-Shop Practice Division
CHARLES W. BEESE, Management Division
G. E. HAGEMANN, Materials Handling Division
J. L. WALSH, National Defense Division
L. H. MORRISON, Oil and Gas Power Division
W. R. ECKART, Petroleum Division
F. M. GIBSON, Power Division
WINFIELD S. HUSON, Printing Machinery Division
M. B. RICHARDSON, Railroad Division
JAMES W. COX, JR Textile Division
WM. BRAID WHITE, Wood Industries Division

Aeronautics

Municipal Flying Field Size

A-1 What size of plot is required for a municipal flying field?

(*a*) It is impossible to designate any definite size for a landing field, because of the many different details which bear on the subject. The Department of Commerce is preparing a list of fields and the Army Air Service has long published such a list. We believe that most of this information can be obtained from these two reports. (C. S. Jones, Curtiss Flying Service, Inc., Garden City, N. Y.)

(*b*) The desirable size depends largely upon the extent to which the field is to be used, the types of aircraft, and the altitude. However, a plot of cleared, well-drained, and nearly level ground of about 2000 ft. by 2000 ft. is satisfactory in most cases. (Archibald Black, Consulting Air Transport Engineer, Garden City, N. Y.)

(*c*) This is dependent upon the size of the city to be served and the aeronautical altitude to be accommodated, but 100 to 400 acres should suffice. (J. E. Whitbeck, Vice-President, Wm. E. Arthur & Co., New York, N. Y. Former Superintendent of Air Mail between New York and Chicago.)

(*d*) A plot of about 2000 ft. by 3000 ft. is advisable. (Alexander Klemin, Professor of Aeronautics, New York University, New York, N. Y.)

Air-Transport Costs

A-2 What is the chief cause of the present high cost of air transport, and will this cost be reduced in the future?

(*a*) Do not believe that any one cause is responsible for the high cost of airplane transportation. Some of the causes are as follows: lack of confidence and knowledge on the part of the general public; lack of suitable airways, which term is intended to mean landing fields, weather reports, lighting, radio, etc.; and lack of volume of business, which makes production in large quantities impossible, thus keeping the price of planes and motors unreasonably high. (C. S. Jones, Curtiss Flying Service, Inc., Garden City, N. Y.)

(*b*) The present small volume of traffic is the chief and almost the only cause of the high rates now charged in air transport. As the volume of traffic grows, unit operating costs will fall rapidly until they approach those of other means of transport. (Archibald Black, Consulting Air Transport Engineer, Garden City, N. Y.)

(*c*) The operation of one or two planes per day over a route and the necessary ground facilities are very expensive. The provision of adequate municipal air ports in all large cities will considerably reduce operating costs, however. (Capt. J. E. Whitbeck, Vice-President, Wm. E. Arthur & Co., New York, N. Y. Formerly Superintendent of Air Mail between New York and Chicago.)

(*d*) Cost of air transport will certainly be reduced. Present high cost is due to high cost of engine maintenance and expense of fuel employed, also the lack of transportation business in proportion to equipment. (Alexander Klemin, Professor of Aeronautics, New York University, New York, N. Y.)

Forced-Landing Causes

A-3 What are the causes of forced landings in airplane operation?

(*a*) The greater percentage of forced landings are due to engine trouble, and in particular to the water cooling system. (Alexander Klemin, Professor of Aeronautics, New York University, New York, N. Y.)

(*b*) The forced landings that occurred in the Air Mail Service between New York and Chicago, for the year 1925, including both day and night flying, were due to:

	Per cent
Power-Plant Failure, 21 per cent, divided as follows:	
Cooling system	29
Ignition	27
Carburetion and fuel	11
Lubrication	8
Miscellaneous: failure of valves, springs, rocker arms, gears, cylinder jackets, etc.	25
Airplane Failure, 1 per cent, welded tube member.	
Weather Unfavorable, 78 per cent, divided as follows:	
Fog and low clouds	68
Heavy snow storms	14
Ice freezing on plane and overloading	12
Cyclones, heavy thunder showers, etc.	6

(Capt. J. E. Whitbeck, Vice-President, Wm. E. Arthur & Co., New York, N. Y., formerly Superintendent of Air Mail between New York and Chicago.)

Fuels

Air Preheating for Boiler Furnaces

F-1 To what extent has air preheating been used for boiler furnaces in this country, and what have been the results?

Preheated air is largely replacing economizers in central-station work, due to the use of extraction turbines. Many industrials are also using preheated air to great advantage. Improvement in efficiency averages from 4 to 7 per cent if economizers are used, the usual figure running from 7 to 10 per cent. These figures are based on sensible heat returned to the furnace. Improvement in combustion conditions may add 2 or 3 per cent to these results. (T. A. Marsh, Western Engineer, Combustion Engineering Corporation, Chicago, Ill.)

Slagging of Boiler Tubes

F-2 What difficulties have been encountered in the slagging of boiler tubes, and how have they been met?

Slagging of boiler tubes usually occurs with low-fusion ash, in furnaces running at high temperature and with high velocity. Usually CO in the gases is a characteristic of a slagging furnace. Methods of improvement are double-spaced tubes, water walls to reduce furnace temperatures, over-fire air to eliminate CO, and larger areas to reduce velocities. (T. A. Marsh, Western Engineer, Combustion Engineering Corporation, Chicago, Ill.)

Purchasing Coal on Specification

F-3 What has been the experience in the purchase of coal on specification? When are samples taken and what method has been found most satisfactory?

If coal is to be purchased on specifications, one must first determine just which coal or coals will produce the cheapest steam, all items considered. This includes:

1 Ability to carry the plant load
2 Reliability of supply
3 Mine equipment
4 Mine preparation
5 Ability of producer to give uniform quality
6 Transportation facilities
7 Adaptability to stoking equipment (installed or contemplated)
8 Service (engineering assistance from coal company)
9 Storage properties of coal
10 Boiler capacity obtainable
11 Maintenance cost of furnaces and stokers
12 Fusion temperature of the ash
13 Labor of firing
14 Responsiveness to meet sudden load demand
15 Amount and density of smoke
16 Cost of ash removal
17 Sulphur content.

These specifications are entirely different from those usually considered. We are not interested in the number of B.t.u. purchased per dollar. We are interested in the coal that will give the lowest ultimate steam cost. Samples should be taken from the cars. (T. A. Marsh, Western Engineer, Combustion Engineering Corp., Chicago, Ill.)

Machine Shop Practice

Oils for High-Speed Drilling

MS-1 What types of oils have been found most suitable for high-speed drilling?

Many commercial oils are supplied for this purpose and representatives of any reputable oil company will recommend oils suited to specific purposes, material drilled being a governing factor. For drilling steel, a mineral oil of medium grade, as used in automobile engines, mixed with a small percentage of lard oil is recommended. (G. H., New York, N. Y.)

Boring a Split Bearing as a Unit

MS-2 What method is used for boring and drilling a split bearing as a unit, either before or after dividing, so that no distortion appears in the finished halves?

A method in successful use by machine-tool builders is to machine off the mating faces of the halves, and then to sweat the halves together with ordinary solder. The bearings are then bored and reamed in a chuck as solid bushings, and external machining is carried out while they are still fastened together. Upon completion of machining they are separated by heating with a torch. (G. H., New York, N. Y.)

Steel Analyses in the Small Shop

MS-3 How may steel analyses be made in a small machine shop without the employment of an expert chemist or the maintenance of costly testing equipment?

This appears to be a rather impracticable thing to carry out, unless possibly some college boy who has studied metallurgy happens to be working in the drafting room or in the shop and can be provided with the necessary apparatus, and allowed the time, to carry out the analysis. It would seem more desirable, however, to submit samples to one of the many commercial analytical organizations which can properly and at small cost furnish complete and authoritative reports covering both chemical and physical characteristics of the samples. (G. H., New York, N. Y.)

Oil and Gas Power

Splitting Oil-Engine Fuel Lines

OG-1 In a power plant containing two oil engines of the solid-injection type, the fuel lines on one engine have split several times. The oil spray in this engine is very fine, while on the second unit the oil is sprayed into the cylinder in a coarse stream. Does the type of spray cause the breakage? If not, what is the cause?

(*a*) The fuel pipes in solid-injection engines are subjected to sudden high pressure rises which cause vibrations and stresses and may cause fatiguing and final breaking of the pipes. Careful fastening of these pipes by means of heavy clamps is necessary to keep the vibrations within permissible limits. If the fuel pump is not rigid, vibrates at each pump stroke, then it will be found difficult to keep critical vibrations out of the pipe, even if the pipes are well strapped to the engine frame. The coarseness of the spray has a bearing on the subject only in that a fine spray generally requires a higher pump pressure than a coarser spray. (R. Hildebrand, Chief Engineer, Diesel Division, Fulton Iron Works Co., St. Louis, Mo.)

(*b*) Probably the cause of the split fuel pipe is either defective piping or excessive pressure in the piping. A careful examination of all parts should be made to make sure that the fuel pressure is not higher than designed. Restriction in the nozzle or adjacent parts could easily cause excessive pressure. (J. W. A., New York, N. Y.)

Railroad

Heat-Treated Steel for Cars and Locomotives

R-1 Why is not more heat-treated steel used by railroads in the construction of cars and locomotives?

(*a*) If heat-treated alloy-steel forgings are referred to, would say that some roads are opposed to forgings of this kind because they will not stand changes in temperature as well as plain-carbon forgings, and also because they do not have the special facilities for replacing such forgings. (James Partington, Manager, Engineering Department, American Locomotive Co., New York, N. Y.)

(*b*) Partly because many railroads are not equipped to handle heat-treated steel and partly because of a dearth of personnel to handle high-grade heat-treating equipment. Safety is a big factor in successful railway operation. Although there would be no difficulty in purchasing cars and locomotives having parts of heat-treated alloy steels, there would be considerable difficulty from the standpoint of the railroads in repairing such parts. There would be no object in using heat-treated steel, unless advantage could be taken of the additional strength and reduction in weight. A heat-treated steel part may not be of the same kind of steel after it has once been repaired in a blacksmith shop. (M. B. Richardson, Associate Editor, *Railway Mechanical Engineer*, New York, N. Y.)

Textile

Conveying and Hoisting Systems

T-1 To what extent are conveying and hoisting systems used in textile mills?

Conveying and hoisting systems are used to a great extent, and very profitably, in connection with coal handling for textile mill power plants. Conveyor systems can be profitably used in certain parts of some textile plants. For example, conveyors for handling bobbins from a spinning room to an outlying weave room, or belt conveyors for handling rolls of cloth to the cloth room from certain central points in the weave room. Gravity conveyors for handling finished cases, rolls or bales of goods are economically used to a large extent. The matter of using conveying systems in any plant is one which should be given careful consideration, as the advisability of installing such equipment depends upon the local conditions of that mill. As a general rule, a great and elaborate conveying system, due to its very principles of handling and its great first cost, up-keep, interest on the investment, etc., will not prove a wise investment. (Earle R. Stall, Textile Engineer, J. E. Sirrine & Co., Greenville, S. C.)

Engineering and Industrial Standardization

Considerable Progress in Standardization Made During New Haven Machine-Tool Exhibition

IN CONNECTION with the technical program of the New Haven Machine-Tool Exhibition, a number of standard committees held meetings which resulted in definite progress.

T-Slots. The technical side of the standardization of T-slots, their bolts, nuts, and cutters, was practically completed at this September meeting of the Sub-Committee. Previous to the meeting approximately 200 sets of page proofs had been mailed to interested firms and individuals. The large number of replies received were carefully reviewed by the members present, with the result that many important improvements were made to this group of standards. This proposal now goes to the Central Committee on the Standardization of Small Tools and Machine-Tool Elements, and on their approval it will be presented to the N.M.T.B.A., the S.A.E., and the A.S.M.E. for approval and transmission to the A.E.S.C. for designation as a Tentative American Standard.

Small Tools and Machine-Tool Elements. The Central Committee composed of representatives of the three sponsors for this project also held a meeting in New Haven and discussed at length the new sub-projects to be undertaken and the order in which they should be approached.

The machine elements now undergoing standardization are (1) T-slots, (2) Tool Holders, (3) Machine Tapers, and (4) Milling Cutters. To this list the Central Committee added the following at this meeting:

(5) Spindle Noses
(6) Collets for Screw Machines, Milling Machines, Lathes, and Grinding Machines
(7) Bushings for Jigs and Fixtures
(8) Machine Sizes, including Planers, Lathes, Milling Machines, Shapers, Upright and Radial Drills, Cylindrical Grinders
(9) Arbors for Shell Reamers
(10) Nomenclature.

Machine Tapers. During the Providence meeting of the A.S.M.E. in May a conference on the standardization of machine tapers was held at which representatives of the manufacturers and users of this important machine element agreed that this project should go forward immediately. Accordingly the organization of the Sub-Committee was carried through during the Summer, and it was called together for its first meeting on September 10.

Milling Cutters. One of the important conferences held in conjunction with the New Haven Machine-Tool Exhibit was that on the standardization of milling cutters. The sponsors had invited approximately 300 manufacturers and users of milling cutters to attend this conference, which was held on Thursday, September 9, at Mason Laboratory, Yale University, New Haven, Conn. Its purpose was to determine the scope of this project and to plan the organization and activity of the broadly representative Sub-Committee which is to undertake this task.

Both manufacturers and users were present in large numbers, and after a two-hour session a resolution was passed recommending the organization of a representative Sub-Committee under the sponsorship for the Standardization of Small Tools and Machine-Tool Elements. This resolution also suggests that the scope of this project include the dimensions of milling cutters which in any way affect their interchangeability.

It will be recalled that at a conference held in Washington, D. C., on March 25, 1925, under the auspices of the Division of Simplified Practice of the U. S. Department of Commerce, the manufacturers proposed for adoption a simplified list of varieties and sizes of milling cutters. That conference approved the simplified list submitted by the manufacturers with the distinct understanding that both manufacturers and users would coöperate in a more complete simplification and standardization of this product under the procedure of the American Engineering Standards Committee with the National Machine Tool Builders' Association, the Society of Automotive Engineers, and The American Society of Mechanical Engineers acting as joint sponsors. The Report of the Simplified Practice Committee of the Milling-Cutter Industry includes revised lists of 35 types of cutters. This group will accordingly be the first to receive careful study by the new Sub-Committee.

Woodruff Keys. In this section of the July, 1926, issue of MECHANICAL ENGINEERING a statement was printed covering the progress made fo June 1 on the standardization of Woodruff keys. During the months following the May 12 meeting of this Sub-Committee a preliminary draft standard was prepared and broadly distributed for criticism and comment.

Numerous suggestions were received by the Sub-Committee and these were discussed in detail at the meeting held in New Haven, Conn., on the morning of September 10. All of these suggestions were constructive in character, and Chairman W. J. Outcalt and Secretary L. C. Morrow were asked to revise certain sections of the table along lines indicated by the Sub-Committee at this meeting. Copies of this redraft will soon be available on application to L. C. Morrow, care of the A.S.M.E., 29 West 39th Street, New York.

Cast-Iron Pipe to Be Standardized

THE first comprehensive endeavor to bring together in a regularly constituted committee under well-established procedure the producers and consumers of cast-iron pipe together with the general interests for the simplification and standardization of this product is now being made. The procedure is that of the American Engineering Standards Committee, and the four sponsors for the Sectional Committee are the American Water Works Association, the New England Water Works Association, the American Gas Association, and the American Society for Testing Materials.

The scope of this project as finally agreed to is as follows: Unification of specifications for cast-iron pipe, including materials; dimensions; pressure ratings; methods of manufacture (including such new developments as centrifugal castings) in so far as they may be necessary to secure satisfactory specifications; elimination of unnecessary sizes and varieties; consideration of the possibility of developing a coördinated scheme of metallic pipe and fittings applicable to all common mediums; and methods of making up joints in so far as they are determining as to the dimensional design of cast-iron pipe.

The types of cast-iron pipe to include: bell and spigot pipe; flanged pipe; flanged and bell-mouth fittings and wall castings; pipe elbows, tees, Y's, return bends, and other fittings not now included in standard lists; cast-iron pipe threaded for flanges or couplings; soil pipe and other light types of cast-iron pipe and fittings. The standardization is not to include methods of installing pipe and similar matters, except as to the making up of joints in its relationship to the dimensional standardization of pipe and fittings, as noted above.

Eleven technical organizations and nine manufacturing firms were invited to appoint representatives. As a result the Sectional Committee is now constituted as follows:

THOMAS H. WIGGIN, *Chairman*
N. F. S. RUSSELL, *Vice-Chairman*
C. C. SIMPSON, *Secretary*
H. E. BATES, WALTER FORSTALL, W. CULLEN MORRIS, and C. C. SIMPSON, representing the American Gas Association
HERBERT HENDERSON, representing The American Petroleum Institute
C. R. KNOWLES, representing the American Railway Engineering Association; C. P. VANGUNDY, Alternate
F. H. STEPHENSON, representing the American Society of Civil Engineers
WALTER S. FINLAY, JR., and J. E. GIBSON, representing The American Society of Mechanical Engineers; GEORGE W. BEGGS, Alternate
S. R. CHURCH, RICHARD MOLDENKE, and C. L. WARWICK, representing the American Society for Testing Materials
F. A. BARBOUR, W. W. BRUSH, W. C. HAWLEY, E. E. WALL, and THOMAS H. WIGGIN, representing the American Water Works Association

C. R. Wood, representing the Manufacturers' Standardization Society of the Valve and Fittings Industry
C. W. Mowry, representing the National Fire Protection Association
W. R. Conard, F. A. McInnes, and C. W. Sherman, representing the New England Water Works Association
R. W. Hendricks, representing the Underwriters' Laboratories
I. J. Fairchild, representing the U. S. Bureau of Standards
W. D. Moore, representing the American Cast Iron Pipe Co.
Kent S. Clow, representing J. B. Clow & Sons
A. M. Campbell, representing the Glamorgan Pipe and Foundry Co.
W. G. Hammerstrom, representing the Lynchburg Foundry Co.
A. M. Ford, representing the National Cast Iron Pipe Co.
Walter Wood, representing R. D. Wood & Co.
Shellman B. Brown, representing the Warren Foundry and Machine Co.
N. F. S. Russell, D. P. Hopkins, and D. B. Stokes, representing the U. S. Cast Iron Pipe and Foundry Co.
Leonard P. Wood, Independent Expert.

This personnel, made up of 11 producers, 19 consumers, and 5 general interests, 35 in all, is now before the American Engineering Standards Committee for approval.

Work Begun on Standards for Drawings and Drafting-Room Practice

THE Sectional Committee on the Standardization of Drawings and Drafting-Room Practice held its organization meeting in New York on Friday, September 24, 1926. Twenty-four members of the Committee and guests were present and a lively discussion followed the transaction of the necessary routine business.

Secretary Rice opened the meeting as a representative of the A.S.M.E., which with the Society for the Promotion of Engineering Education is joint sponsor for this project. His greeting was followed by one from Dr. P. G. Agnew, Secretary, American Engineering Standards Committee. Dr. Agnew referred to the general conference on this subject which was held on December 4, 1925, distributed to the members of the Committee copies of an elaborate report which had been prepared by a special committee appointed by that conference, and expressed the belief that the findings of this Special Committee would prove to be of considerable value to the Sectional Committee and its sub-committees.

The Committee then considered the results of the sponsor societies' efforts to form a committee which would be fully representative of all the national organizations in any way interested in this project. In this correspondence Prof. Thomas E. French, of Ohio State University, has represented the S.P.E.E. and C. B. LePage has represented the A.S.M.E. Forty-seven organizations were invited to appoint official representatives. Of these twenty-four have made appointments, eight have declined, and fifteen have yet to be heard from.

The Committee then proceeded to the election of temporary officers. Prof. Franklin DeR. Furman, professor of machine design, Stevens Institute of Technology, was chosen temporary chairman and Carl W. Keuffel, of Keuffel & Esser Co., temporary secretary.

During the discussion a number of those present recommended that invitations to appoint representatives be extended to the organized groups representing the trade high schools, the corporation schools, and other vocational schools and institutes.

The Committee voted to meet again during the first week of February, and requested the chairman in the interim to appoint three sub-committees to undertake the several parts of the project. Among those present were the following representatives of the organizations named:

Lt-Col. R. G. Alexander, U. S. Military Academy
A. V. Bouillon, American Marine Standards Committee and Society of Naval Architects and Marine Engineers
Davis S. Boyden, American Society of Heating and Ventilating Engineers
C. W. Burke, American Electric Railway Association
A. A. Coburn, U. S. War Department
Wm. H. Copithorne, Bell Telephone Laboratories
T. G. Crawford, American Institute of Electrical Engineers
Howard C. Fletcher, U. S. Navy Department
F. DeR. Furman, Society for the Promotion of Engineering Education
Oliver S. Hagerman, American Gas Association
E. W. James, U. S. Bureau of Public Roads
Carl W. Keuffel, Manufacturers of Equipment
Harry M. McCully, Society for the Promotion of Engineering Education
S. P. Melville, Association of Edison Illuminating Companies
Geo. L. Quigley, American Institute of Consulting Engineers
W. H. Rademacher, Illuminating Engineering Society
Geo. Schobinger, Member, American Society of Civil Engineers
Fred G. Wolff, American Railway Car Institute.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Standardized Machine Fits

To the Editor:

The American Society of Mechanical Engineers has issued a report (B4a-1925) entitled American Standard Tolerances, Allowances and Gages for Metal Fits, in which there is offered to designers a choice of eight different fits, each with a specified tolerance and a specified division (usually half and half) of the total tolerance between the hole and the shaft.

This proposed standardization appears to be primarily intended for users of limit gages. It is the purpose of the following to consider how the adoption of these standards would affect the cost and quality of product manufactured to measuring instruments instead of limit gages, and whether industry would be benefited by such standardization.

The best or ideal machine fit depends solely on requirements of the product, variously involving such factors as the speed, load, length, lubrication, and duty of a bearing, or the materials, sections, length, finish, and force requirements of a force fit. The fit problem is therefore concerned only with the quality or performance of the product.

Both quality and cost enter into the determination of tolerance, while division of tolerance between hole and shaft is mostly a shop problem in terms of cost, based on the sizing operations. If we need less tolerance in grinding than in reaming the holes there is an excess tolerance, available in a flexible measuring system, for cheapening the shafts.

The proposed standardization of fits, tolerances, and divisions of tolerance would restrict free choice as to all three, and could be employed only with corresponding sacrifice as to both quality and cost of the fits produced.

Fig. 1 is a diagram based on the proposed standardization as applied to 2-in.-diameter fits. The distance to the horizontal or zero line is interference or clearance. The center of each circle is at the mean or "selective" fit. The diameter of each circle is the gage tolerance of that fit, all from the tables of B4a.

With a flexible measuring system of production all fits along the inclined line are equally available to the designer and manufacturer. It is not assumed that all are equally useful to industry, but it is evident that any intermediate fit, such as P, in the center of the running-fit zone, is more useful than either of the standardized fits No. 2 or No. 3. A preference for fits Nos. 2 and 3 is either arbitrary or else based on a custom of purely accidental origin in industry, and of only such importance as may be derived from established practice.

With the proposed standardization, a designer whose calculations or experience calls for fit P must choose either No. 2 or No. 3 of the standardized fits, and the results, if he chooses No. 2, may be read as follows from the diagram.

The restriction of choice of fit due to standardization causes an error of 0.0007 in. in the mean fit, which error is 23 per cent of the entire fit difference, and it permits an actual deviation in one direction of double that authorized by the normal tolerance. The restriction of choice of fit has the effect of an error of 0.0011 in. in the not-go snap gages of both the operator and the inspector. It completely upsets the plan of control to limits.

Similarly at force fit R the designer must accept an error of 33 per cent of the total fit difference and consequent force in pressure desired. In other, but perhaps less-used groups, the results of restricted choice of fit are still worse. The average is half these extreme errors in each group of intermediate fits between the standardized fits.

The further errors and increased cost imposed by standardization and restricted choice of tolerances, and divisions of tolerance between hole and shaft, are calculable only in view of the operations of production, but the tolerances standardized are so large in proportion to the total fit differences that this further increased cost and impairment of product must be quite large in many cases.

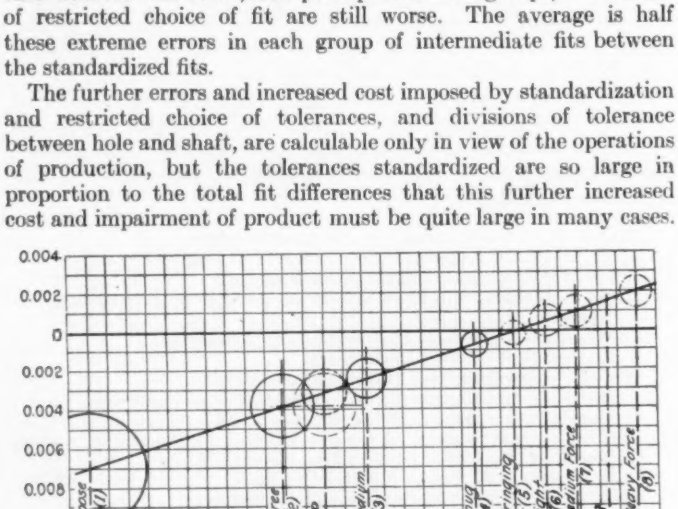


Fig. 1 Diagram Based on Proposed Standardization as Applied to 2-In.-Diameter Fits

(Distance to zero line is interference or clearance; center of each circle is at mean or "selective" fit; diameter of each circle is gage tolerance of that fit.)

In return for this cost and loss from standardization there appears to be no considerable gain to the mechanical industry in general. In almost all machinery the fitting parts are all made by the same manufacturer or to his exact specifications. Even if uniformity in practice were desirable this proposed standardization of fits would not lead in that direction, because it does not standardize the uses of the arbitrarily standardized fits. At 650 r.p.m. and 550 lb. per sq. in., there is equal authority for using standardized fit No. 2 or No. 3. Two designers are just as likely to choose the extremely opposite fits as the same fit for the same purpose. The adoption of a simple speed-load-fit formula and a flexible measuring system of production would succeed where the proposed standardization would fail, if uniformity of practice be desirable.

A few mechanical products such as pulleys, gears, couplings, and ball and roller bearings must fit exchangeably on motors, drawn shafting, and other machinery, but this demands special coöperation and compromises which are not helped at all by the proposed standardization of all fits without standardization of their uses, nor does it appear that such extensive and costly standardizing, involving running and forcing fits, would be advisable, even if it could be effective, for such a limited need.

Reamer manufacturers do not plan to carry in stock the four classes of variously oversize reamers which would be required to effectively utilize the proposed tolerances in reamed holes. A new 1-in. reamer may cut only 0.0002 in. in diameter oversize, and after the initial wear it would not do much work if it had to be thrown away when down to size. Therefore adjustable, expansion, or special reamers must be employed for these standardized fits, and the standardization promises no benefit in cost of tools.

Limit gages would not be sized in such quantity as to offer any advantage in their cost and investment to a manufacturer who stores his gages with the special tools for the job.

Adoption of the proposed standardized fits and limit gages might greatly benefit the manufacturer who uses limit gages stored by size, for use on any job. It would reduce the number of his limit gages from an endlessly increasing number to such of the several hundred proposed standard sizes as his class and range of production might require. It is doubtless for such good purpose that the proposed standardization is offered. It would minimize the difficulties arising to the users of limit gages, due to the inflexibility of that system of measurement.

The manufacturer using a measuring system instead of limit gages would gain practically nothing from the proposed standardization in return for his surrender of the complete flexibility of a production system which enables him to exactly produce any combination of fit, tolerance, and division of tolerance at an extra cost never exceeding that for a plain cylindrical "Comparator" standard or disk.

P. J. Darlington.[1]

Brookline, Mass.

A.S.M.E. Boiler Code Committee Work

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

Revisions and Addenda to Boiler Construction Code

It is the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision in the Rules in its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has recently received and acted upon a suggested new specification for hollow-forged seamless steel drum forgings which has been approved for publication as addenda to Section II of the Code. This specification is published below and is submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as an addition to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

Proposed Specifications for Hollow-Forged Seamless Steel Drum Forgings

1 *Process.* The steel shall be made by either or both the following processes: open-hearth or electric furnace.

2 *Discard.* Sufficient discard shall be made from the top and bottom of each ingot to secure soundness in the portion used for the drum forging.

3 *Forging.* The forging shall be made from a solid cast ingot, punched, bored, or hot trephined.

The resultant wall of ingot shall be reduced in thickness at least one-half by forging on mandrels.

4 *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

[1] Owner, Manager, and Engineer, Microgage Company, Boston, Mass. Mem. A.S.M.E.

	Class 1	Class 2
Carbon, maximum, per cent	0.35	0.45
Manganese, per cent	0.30–0.65	
Phosphorus, maximum, per cent.. Acid	0.04	
Phosphorus, maximum, per cent.. Basic	0.035	
Sulphur, maximum, per cent	0.04	

5 *Ladle Analyses.* An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of the elements present. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Par. 4.

6 *Check Analyses.* As a substitute for check analyses in the general rules, the purchaser may make an analysis from a broken tension-test specimen representing each drum forging. The chemical composition thus determined shall conform to the requirements specified in Par. 4.

7 *Heat Treatment.* Prior to taking test specimen, the whole of the forging shall be simultaneously annealed above its critical temperature. If additional forging is required after taking test specimens the whole of the forging shall again be simultaneously reannealed above its critical temperature, but not above the temperature of the first anneal.

8 *Tension Tests.* The forging shall conform to the following requirements as to tensile properties:

	Class 1	Class 2
Tensile strength, min., lb. per sq. in.	60,000	75,000
Yield point, min., lb. per sq. in.	0.5 Tens. Str.	0.5 Tens. Str.
Elongation in 2 in., min., per cent	26	24
Reduction of area, min., per cent	42	38

9 *Bend Tests.* The test specimen shall withstand being bent cold through 180 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

10 *Test Specimens.* *a* Tension and bend-test specimens shall be taken from full-size prolongation of each forging after annealing, as provided for in Par. 7.

b One tension-test specimen shall be taken from each end of the forging. The axis of the specimens shall be located midway between the inner and outer surfaces of the wall parallel to the axis of the forging, the two specimens being taken from diagonal corners of an axial plane. Tension-test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

c One bend-test specimen shall be taken from the end of the forging corresponding to the top of the ingot. The axis of the specimen shall be in a diametral plane perpendicular to the axis of the forging. The bend-test specimen shall be 1 in. by $^1/_2$ in. in section, with edges rounded to $^1/_{16}$ in. radius.

11 *Number of Tests.* *a* Two tension tests and one bend test shall be made for each forging.

b If any test shows defective machining or develops flaws it may be discarded and another specimen substituted.

c If the percentage of elongation of any test specimen is less than that specified and any part of the fracture is more than $^3/_4$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, the specimen shall be discarded and another taken.

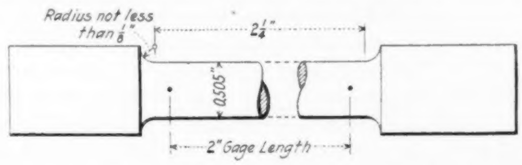


FIG. 1 STANDARD FORM OF TEST SPECIMEN REQUIRED FOR ALL TENSION TESTS OF STEEL SEAMLESS HOLLOW-FORGED MATERIAL

12 *Retests.* If the results of the physical tests of any forging do not conform to the requirements specified, the manufacturer may reanneal the forging and retests shall be made as specified.

13 *Permissible Variation.* The thickness of the parallel wall of each forging shall not be less than that specified. If the thickness of a portion of the wall of the forging is less than that specified, due to accidental or unavoidable irregularity of bore, the forgings may be accepted by the purchaser, provided such irregularity will not require lowering of the allowable working pressure below that for which the drum is designed.

The overweight limits are considered a matter of contract between the manufacturer and the purchaser.

14 *Finish.* The forging shall be free from injurious defects and shall have a workmanlike finish.

15 *Marking.* Each forging shall be legibly stamped by the manufacturer at each end with the name of the manufacturer. manufacturer's test identification number, and minimum tensile strength specified for the class of forging. The manufacturer's test identification number shall be legibly stamped on each test specimen.

Railway-Equipment Tests at Purdue University

IN AN EFFORT to bring about still greater safety to passengers and to increase their comfort, as well as to effect a continued reduction in loss and damage claims to freight shipments and railway equipment, two very important investigational programs are being carried out at the Engineering Experiment Station of Purdue University, Lafayette, Ind. The first of these has to do with braking equipment and is being conducted by the American Railway Association. The investigation involves the most thorough and elaborate series of tests of train brakes ever undertaken in the world. The second series of tests is being conducted by the university in coöperation with the American Railway Association and will involve a thorough study of draft gears used on both freight and passenger cars.

The purpose of these tests is to determine what improvements can be made in respect to the present standard of brakes now used by the railroads of this country.

The tests, which began back in November, 1925, and which are expected to cover a period of several years, are being conducted in a separate building which has been especially set aside for the purpose of this investigation at the university. Here has been installed the complete air-braking equipment from two modern locomotives, as well as the brake equipment from one hundred freight cars, so that the tests watched by the railroad executives were equivalent to tests that would come from the actual operation of a train consisting of two locomotives and one hundred freight cars on a railroad.

Most of the time so far has been devoted to the testing of the present standard brakes now in use on the railroads of this country with a view of providing a basis of comparison for subsequent investigations. Later, brake equipment which manufacturers claim will prove to be an improvement over the present standard will be tested. Upon completion of the work at Purdue, various brake devices will be given road tests for the purpose of developing whether or not they meet practical road conditions satisfactorily.

The cost of the project up to October 1 was over $300,000.

The machine for testing draft gears, which is now being constructed by the Olsen Company of Philadelphia, Pa., will be the largest that has ever been used for the purpose. A novel feature of the machine will be two falling weights, the larger one weighing 27,000 lb. and the smaller one 9000 lb., the latter being the weight most frequently used heretofore in similar test machines. The machine will be driven electrically, the control equipment being so designed that operation may be manually or automatically controlled. It will be equipped with various devices to record the action of draft gears under various tests. The machine when completed will be installed at Purdue in a special building now being erected to house the new equipment, and it is expected that the tests will be started about January, 1927.

MECHANICAL ENGINEERING

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Safety and the Holland Tunnels

THE OPENING of the Holland vehicular tunnels early in the spring of 1927 may be expected to bring the usual chorus of protestations and predictions of disaster from the doubting Thomases. To counteract any adverse impressions that they may create regarding the safety of these new traffic arteries between New York and New Jersey, it may be well to bear certain facts in mind and to use them in attempts to convert these doubters as quickly as possible.

Let it be known that those who dreamed of an underground roadway for motor vehicles realized better than the doubters the dangers accompanying the release of vast quantities of carbon monoxide in an enclosed space occupied by human beings. So well did they realize this that they caused to be made the most elaborate series of tests in the history of tunneling to settle the permissible concentration of this deadly gas and to determine the necessary constants permitting them to design adequate ventilating equipment. A careful study of the results showed that a concentration of 4 parts of CO in 10,000 parts of air can be endured for one hour by the average individual with safety.

The necessary constants for designing the ventilating apparatus were determined at the University of Illinois in a specially constructed tunnel equipped to reproduce the various conditions desired.

Equipped with the necessary facts, the designers then proceeded with the ventilating system. They first considered the plan of driving the necessary fresh air through the tunnel from end to end, but calculations revealed gale-like currents which would make the operation of vehicles difficult. They next divided the tube into three sections, that below the roadway being fixed as the fresh-air passage and that above the ceiling of the traffic section as the vitiated-air duct. Fresh air will be admitted to the tunnel through continuous slots a few inches above the pavement and will spread out over the floor in a sheet with no perceptible disturbance. Rising, it will carry the foul gases to the ceiling, where they will be drawn through vents into the exhaust duct.

To effect a complete change of air every $1^1/_2$ min. will require the staggering figure of 3,750,000 cu. ft. per min. This load will be carried by four stations, two at each pier head and one between each of these stations and the terminus of each tunnel. The buildings housing the equipment rest directly above the tubes, affording direct communication with the ducts. A total of 84 fans will be supplied, with 56 of these in operation normally, one-third of the capacity being held in reserve. Extra precautions have been taken to insure continuous power. Current will be available from three sources on each side of the river, each being of sufficient capacity to carry the entire load. Provisions have been made at each terminal for handling stalled cars within the tunnel, reducing tie-ups to a minimum. Block signals placed at frequent intervals will permit instantaneous communication with the entire traffic line. Fire plugs and hose lines will be available every 120 ft. Telephones will be but 480 ft. apart. The roadway will be brilliantly lighted by the latest type of illuminating system, with the fixtures installed flush with the walls and well out of harm's way.

A most comforting fact relates to the personnel of the engineering staff. Upon the death of C. M. Holland, the first chief engineer, M. H. Freeman was chosen from the ranks to succeed him. He, too, died within a few months, and again the breach was filled by a member of the staff, the present chief, Ole Singstad. Let the cautious ones consider for a moment the class of product likely to be turned out by an engineering force of such caliber that three chiefs may be chosen from its ranks without interrupting the work and without deviation from the course originally charted.

Inspection Keeps Pace with Production

WHEN the astonishing development of mass production of interchangeable mechanisms is considered, a thing often overlooked is that there has at the same time been an equally astonishing development in mass inspection.

Successful interchangeable manufacture antedated even reasonably accurate measuring systems, in spite of the fact that the very foundation of this system is accuracy. In the 1850's, when the interchangeable manufacture of firearms had reached a really advanced stage, the criterion of accuracy in many a large plant was a steel or boxwood scale of questionable length, questionably divided into sixteenths of inches. The procedure under these conditions was to make up a master gun to the closest accuracy possible, and then to make tools, jigs, and gages to fit this master. As a result every one of the stand of arms was like the master, and interchangeability existed throughout the stand of arms but not beyond it.

With the general introduction of the micrometer and its related tools of extreme accuracy, interchangeability became general instead of local, and the system at last fully deserved its name. As micrometer accuracy was transferred, together with the skill and even the intelligence of mechanics, to automatic production machinery, it was very soon apparent that if old-fashioned methods of inspection were to continue, then the force of inspectors would soon far outnumber the production force.

The obvious remedy was some form of automatic inspection which would permit a few relatively unskilled inspectors to keep pace with the automatic production machines. With the help of science this is actually being accomplished, and in the inspection departments of many well-known plants will now be found complicated pieces of laboratory apparatus which are working hard day in and day out upon such practical tasks as checking threads of bolts, the shape and size of gear teeth, etc. It is obvious that the checking of either a screw thread or a gear tooth is a task for an expert when directly considered in terms of split thousandths. When, however, either is projected upon an accurate drawing 100 times full size, it may almost be said that "he who runs may read," and inspection becomes a matter of a glance.

Then, too, there are devices which make use of sensitive electromagnetic "fingers" to distinguish between the accurate and the inaccurate. Parts are run rapidly through these machines on a conveyor belt, and as the "fingers" feel the vital surfaces, those pieces whose dimensions do not have the necessary degree of accuracy are automatically sidetracked.

The application of electricity to inspection is not limited to these relatively simple electromagnetic devices. The audion tube and the photoelectric cell are likewise being pressed into service. By means of the audion tube it is now possible to check surfaces for smoothness and to rate the degree of smoothness in positive terms. By the use of the photoelectric cell it is now possible to sort parts according to their color and to detect by this artificial eye variations in shade which would escape the notice of the human eye.

The list of new inspection methods based upon pure science might be extended to great length but their importance can scarcely be fully appreciated until a careful study is made. It is expected that within the next few months the readers of MECHANICAL ENGINEERING will be given opportunities to learn more about the new technique of mass inspection through papers presented by experts who are pioneering in this field.

"Dedicated to the Public"

IN THE U. S. Patent Office *Official Gazette* of Aug. 24, 1926, p. 720, is printed in small type an official notice with a big meaning. In it the Royal Typewriter Company announces that it dedicates to the public the enjoyment of its patents on a certain clutch-operating mechanism. The reason for this somewhat unusual act is that the purpose of this mechanism is to safeguard industrial workers from injury, and the company desires that it be used with the utmost freedom without any compensation to it and without the restriction that patent fees might create.

This is not the first instance of such a generous attitude of mind. James Nasmyth, the inventor of the steam hammer, designed a worm gear for tilting foundry ladles which obviated to a considerable degree the formerly existing danger of the metal splashing on the men. He sent out to numerous foundries a description of his device, announcing at the same time that he would not take patents on it and that any one was free to use it.

A still more modern instance of this is the action taken by the Diamond Match Company shortly before the World War. Up to that time phosphorus was extensively used in the manufacture of matches. Notwithstanding all attempts to make its use safe to workers in match factories, phosphorus poisoning with all its horrible consequences was quite common, until finally Congress began to consider the enactment of a law that would, in the interest of public safety, prohibit the use of phosphorus in matches completely. An objection was made by some manufacturers that the Diamond Match Company was the only one in this country which controlled a patented process for making matches without phosphorus, and the passage of the proposed law would either give it an absolute monopoly of match manufacture or enable it to charge its competitors exorbitant license fees for the use of its patent. It was then that the Diamond Match Company announced that it would permit a free use of its patented process by any American manufacturer, provided the law prohibiting the use of phosphorus was passed.

There have been many other instances of this character, both in this country and abroad and it is highly gratifying, from a human point of view, to see large companies forego possible profits in order that no impediments shall be placed in the way of saving life and health of workmen throughout the country. This tendency may result, however, in reducing the volume of invention in a very important field by removing the stimulus that prompts the individual inventor, and thus retard rather than forward safety work.

Steam-Boiler Development

WITH the rapid developments in steam-boiler practice during the past few years, many problems have arisen that appear to give concern not only to the boiler manufacturer, but also to the inspection departments responsible for the safety of boilers and pressure vessels. The increasing demands for heat economy, particularly in connection with the large power stations now coming into use, have boosted operating steam pressures up from former maximums of 350 and 400 lb. to 600, 900, and 1200 lb. The critical pressure of steam, 3300 lb., is also suggested.

The grave questions concerning pipe connections and fittings, gaskets, packing, etc., for these higher pressures appear capable of satisfactory solution. The several installations operating at 1200 lb. or more have apparently overcome such problems with a reasonable degree of satisfaction, and research concerning the effect of the extremely high temperatures encountered at such pressures is developing a tremendous amount of valuable information concerning the characteristics of metals and alloys that are most suitable for the various classes of service.

One of the most striking features of this development is the fact that with drums of relatively small diameters these high pressures demand shell thicknesses that exceed the practical limits of riveting for the joints. This has influenced the use of forged seamless drums and here the valuable experience developed in heavy forging of large-bore rifles, hydraulic cylinders, etc. is turned to the advantage of the boiler manufacturer. This development has, it may be stated, revealed the necessity of introducing a new specification for the material required for such forgings, but the Boiler Code Committee in coöperation with the American Society for Testing Materials has been able to meet this need of industry. Such a specification has just been approved for publication as an addendum to the Material Specifications Section of the Code and appears in this issue.

With drums of such great shell thickness the attachments of nozzles or other fittings for outlet connections and the like have demanded treatment that is relatively new in steam-boiler practice. In some instances it has been found possible to forge down an end of the drum and machine directly upon it a pipe flange for connection to header or main stop valve. In others where a nozzle at the side is desired it is found more satisfactory to fasten the flange plate or nozzle fitting with studs instead of rivets, the thickness of the shell affording ample depth of thread. It has even been proposed to insert the end neck of a long-bodied nozzle through a drilled hole in the shell of such a thick drum and expand it at the inner end like a boiler tube, and it is of course generally recognized that such a plan has merit.

Not alone in the problem of shell construction are difficulties encountered in high-pressure-boiler design—all fittings and attachments require special treatment and in many instances different materials of construction. Feed connections and piping, blow-off piping and valves, and steam and water gages all require special design as well as special materials. Brass and bronze are frowned upon by the Boiler Code for use at pressures in excess of 200 lb. per sq. in., as at the temperatures accompanying such pressures a pronounced weakening of the material is to be noted. Almost a new art has been developed in water-gage, steam-gage, and safety-valve construction.

Broadly viewed, the art of boiler construction seems to be inclined to depart from its accustomed channels of practice for many years past, and it is indeed a study of the greatest interest to observe the tendencies toward which it is drifting. It is a general impression that important new developments are still to appear in this field.

Standardized Drafting Practice

THE organization on September 24 of the A.S.M.E. Sectional Committee on the Standardization of Drawings and Drafting-Room Practice marks the beginning of a work which is certain to have a pronounced effect in the promotion of engineering efficiency. While the initial problems of this committee will be those of sizes of drawings, use of lines and symbols, arrangement of views, etc., eventually much broader subjects will come up.

These initial problems are themselves extremely important in that their solution will insure that engineers everywhere will use the same "sign language" and therefore will understand each other perfectly when exchanging ideas and information by means of drawings, even though they have never seen each other and do not come into personal contact at all during the carrying out of an engineering project.

The ways in which this work will promote engineering efficiency in its broader aspects may not be at once evident to those who have not at sometime struggled with the obstacles which have arisen as a result of poorly planned drafting systems. For instance, think of the matter of numbering of drawings. When a new design is being developed, especially by a new concern, all interest usually is concentrated upon the machine itself, and in the rush to get it on paper and to get the drawings into the shop, scant attention may be given to the numbering system.

It is only after the product is under mass production and upon the market that the importance of the numbering of its parts is realized. If, happily, a sensible system was chosen in the beginning, then its beneficial effects will be felt throughout the entire organization and will even extend to the customers when repair parts have to be ordered. If, on the other hand, the system was ill-chosen, then confusion will be increasingly apparent as time goes on and will

soon reach a point when it will be unbearable. Such confusion can only be overcome by renumbering, and this is an expensive and very troublesome process.

Substantial beginnings in drafting standardization have been made by many big industries, and the new committee is assured the hearty coöperation of these organizations and the full benefit of their years of experience. The coördination of such experience will immediately lay the basis of codes which other companies, particularly those just starting out their careers, will do well to follow.

The Annual Meeting

AN UNUSUALLY large number of important papers are listed on the tentative program for the coming Annual Meeting which is to be held in New York during the first four days of the week beginning December 6, 1926.

Monday will be taken up with the usual Council meeting, committee meetings, and conference of Local Sections Delegates, the program opening on Monday evening for the informal get-together which has developed into a huge success in the past few years. Tuesday morning the technical sessions start, and continue through Thursday afternoon. The program of these sessions was given in the October 22 issue of the *A.S.M.E. News* and includes the titles of the papers to be presented. On Tuesday evening, William L. Abbott will deliver his Presidential Address, and the new president, Charles M. Schwab will be inducted into office. As a special feature of the coming meeting, the Society will have the honor of incorporating in its program the ceremony of the award of the John Fritz Medal to Dr. Elmer A. Sperry, a member of the A.S.M.E. This award was announced on October 15.

The Society dinner will be held on Wednesday evening, December 8, at the Hotel Astor, at which there will be a number of interesting short speeches, followed by other enjoyable entertainment.

As in the past few years, the Annual Meeting will be paralleled by the National Exposition of Power and Mechanical Engineering to be held in the Grand Central Palace, New York. Over five hundred exhibits of all types of power and mechanical apparatus will fill four floors of the Palace during the entire week.

The Campaign to Secure a National Department of Public Works

SINCE the First Public Works Conference, held in conjunction with the Annual Meeting of American Engineering Council, in January, 1924, the Jones-Wyant Public Works Bill has been adopted by the engineers and those associated with them in the public-works movement, and introduced into both houses of Congress. Action has not been secured on this measure although opportunities have been sought for such action continuously.

The general reorganization bill proposed by the Administration has been approved by representatives of American Engineering Council, but it has been felt that its chances of success were so slight that concerted effort of the engineers could not be asked for, nor has the financing of the public-works movement thus far justified general support for any measure other than the Jones-Wyant Bill.

The Administration measure was backed because it was felt by many engineers that if the small board proposed in that measure could be created there would be a better chance to secure early and effective action on the public-works plan sponsored by engineers. In this measure it was proposed to leave the transfer of certain bureaus to the President upon the recommendation of a special board created by the bill. If this bill could have been enacted into law it would not be necessary to secure a special act of Congress to effect the transfer of each of the bureaus. Since it was impossible to get the reorganization board measure before Congress during the last session, the way has again been opened for special public-works legislation along the lines proposed in the Jones-Wyant Bill. The plans for a reorganization board failed because Congress objected to placing so much authority in the hands of the President and the small board.

Committee on Organization of Federal Public Works Established

In anticipation of the objections sometimes raised against the proposed Department of Public Works, officials of American Engineering Council decided to develop a sound internal plan of organization for the proposed department. To do this the leading engineering organizations of the country concerned with organization problems were called upon to nominate engineers who were the outstanding recognized authorities on such problems to constitute a committee to develop a sound plan of organization for the engineering functions of the Federal Government. In this way it is believed that the best engineering talent has been obtained to render an outstanding public service to the Federal Government. Hubert Work, Secretary of the Interior, has been interested in this plan and has coöperated by naming Dr. Elwood Mead, Director of Reclamation, as his representative on the Committee. The other members of the committee are: E. O. Griffenhagen, Chairman, Wallace Clark, Col. John Price Jackson, Col. Sanford E. Thompson, Dr. W. F. Willoughby, and J. L. Jacobs.

The objective of this committee is to analyze the public-works and public-domain functions of the Government to determine the practicability and desirability of a complete or partial merger of all such functions in the proposed new department, and to work out the best plan of internal organization for the department in which such functions should be combined.

This committee is free to develop that organization layout which is best suited to the most efficient and effective organization of the new department. Their recommendations will be submitted to American Engineering Council for approval before they are finally adopted.

It is contemplated that the present Jones-Wyant Bill, S-2605 and H. R.-7980, will be sufficiently broad to cover the recommendations of this committee since it only authorizes the transfer of bureaus and offices to the proposed department and does not refer to their organization. However, should changes be found necessary they will be made by amendments. Both Senator Jones and Congressman Wyant have been kept informed of the work of this Committee and will doubtless be willing to include any changes which the Committee may recommend. Effort should therefore be concentrated on the Jones-Wyant Public Works Bill as at present written. The report of the Committee, it is hoped, will be ready for distribution early in November.

Organization of State Committees

Plans for the organization of state committees to handle the public-works campaign in each of the states, have been under way continuously. State chairmen have been appointed and have taken up the work in 34 states, and complete committees have been organized in most cases to handle the state work along the lines which have been outlined in detail to the committees. It is contemplated that practically all of the states will be completely organized before Congress reconvenes in December, so that all members of Congress will be advised direct from their own constituents as to the attitude of engineers on this important problem.

In addition to this a great deal of personal work has been done with the individual members of both the Senate and House when they have been in Washington, so that it is contemplated that the effort of engineers to secure a National Department of Public Works is having far-reaching effect. The effort will now be to consolidate the gains made and to push forward to final success.

Senator Wesley L. Jones and Congressman Adam M. Wyant are both intensely interested in this measure and will push it at the next session of Congress. In addition to this many other senators and congressmen, and at least two members of the Cabinet, have definitely endorsed the public-works measure and will be of great assistance in the forthcoming effort to secure legislative action.

It will be necessary to secure a hearing on the measure before the bill is taken up on floor of the Senate or House. It will therefore be our first effort to secure favorable action by the Senate Committee on Public Lands and Surveys, or the House Committee on Civil Service, to which the Senate and House bills were respectively referred. After presenting our case to the committee and securing a favorable report on the bill, it will be necessary to carry the campaign for the enactment of the legislation to the floor of both the Senate and the House. Concerted effort of all the engineers will be required to accomplish this during the next session.

The Old Dominion Meeting at Richmond, Va.

Five-Day Convention of Novel Type Comprising Technical Sessions, Shipyard and Aeronautic-Field Visits, and a Pilgrimage to Neighboring National Historic Shrines

THE "Old Dominion" Meeting of the A.S.M.E. combined technical sessions, excursions, entertainment and a pilgrimage to the historic shrines of the nation. The result was an unusual and highly enjoyable program. The meeting started in Richmond, Va., on Monday, September 27, and continued there until noon on Wednesday, when the party left for the trip to Norfolk, arriving in Washington, D. C., on Friday morning, October 1.

The entertainments were conducted with delightful cordiality and informality. On Monday the ladies were entertained at luncheon, and taken on an automobile drive and for tea to the homes of the wives of the Richmond members. In the evening there was an informal gathering at the Hotel Jefferson. Tuesday afternoon the men were taken about the city in buses with well-informed guides who proudly pointed out the historic spots. In the meantime the ladies were being escorted through the historic lands outlying Richmond and entertained at both luncheon and tea. Tuesday evening, preceding the important technical session which was addressed by eight outstanding mechanical engineers, a buffet supper was served at the Hotel Jefferson.

Wednesday noon the party left on a pilgrimage through the historic section of Virginia, which contained the first settlement of English people on the continent, the scenes of battlefields of three great wars, and the field of great activity during two others. Jamestown was the first stop, and here the pilgrims visited the remains of the early settlement. At Williamsburg they visited Bruton Church and the College of William and Mary. The party returned to Jamestown to board the *Southland* for the rest of the trip. Thursday morning the boat docked at the plant of the Newport News Shipbuilding and Dry Dock Company. The party disembarked and was given an opportunity to view the construction of a number of vessels. The boat then crossed to Norfolk, where luncheon was served at the Hotel Monticello by the Norfolk Engineers' Club. Reëmbarking, the party left for Fortresses Monroe and Hampton. During the trip a technical session was held at which Prof. H. L. Seward gave his paper on Fuel Conservation in the U. S. Government Merchant Marine Fleet. On arrival at Hampton, the Hampton Chamber of Commerce provided automobiles for a visit to Langley Field to see the hangars, the Langley Memorial Aeronautic Laboratory, and the balloons. Upon return to the boat the party ascended the York River to Yorktown.

The "Old Dominion" Meeting in its concept and conduct marked a new type of gathering of engineers, and its successful culmination is due to the splendid efforts of the Richmond Committee: Allen J. Saville, Chairman; J. Ambler Johnston, Arthur Scrivenor, Charles Loeber, H. B. Hawkins, and A. C. Dunn. Graham Bright and C. C. Robinson gave special assistance in the conduct of the two-day, trip, and Mrs. Arthur Scrivenor acted as hostess for the ladies.

Textile Session

James A. Campbell, Chairman of the Textile Division, presided at the Textile Session held on Tuesday morning, September 28. Col. F. M. Gunby presented the first paper, that on the Cotton Textile Industry, written jointly by Charles T. Main and himself. This paper appeared in the October issue of Mechanical Engineering. The second paper, on Power Losses in Cotton Textile Mills, was presented by George Wrigley. These two papers will be presented for further discussion at the coming Annual Meeting in December.

Wood Industries Session

The Wood Industries Session was also held on the morning of September 28. William Braid White, Chairman of the Executive Committee of the Wood Industries Division, presided throughout the session.

Four papers were presented. The first two were by J. A. McKeage[1] and were entitled: Circular Saws and Their Cutting on Various Woods, and Modern Sawing Machinery. The first of these papers was published in the October, 1926, issue of Mechanical Engineering, while the latter appears elsewhere in this issue. A paper on Circular-Saw Machinery for the Cutting Room, presented by C. L. Babcock,[2] discussed the various types of machines used by manufacturers of pianos, furniture, and other cabinet work, for sawing the stock to size in the cutting room. The last paper, by Arthur Blake,[3] on Modern Pattern-Shop Equipment, described the general layout and machinery required for a large pattern shop.

In opening the meeting the chairman described briefly the present conditions in the industry, mentioning their tendencies to deplete the supply of raw material, and emphasized the importance of getting away from the old appellation of "wood butcher" and placing the industry on a sound mechanical basis. The papers and discussion seemed to indicate that before very great strides could be made in conservation through manufacturing methods, there must be an effort at standardization. The matters of teeth cutting, sharpening, and setting all must be standardized. Higher speeds are desirable in order to produce smoother surfaces for joints without the usual planing operation and its resultant waste. One of the obstacles mentioned was the difficulty of obtaining the steel required to withstand the high speeds without distortion of the saws, and better coöperation in this respect with manufacturers was needed. A tendency on the part of some mills toward hollow-ground saws was mentioned. Motorized sawing equipment had gained in favor, it was shown, about 50 per cent of all sawing machinery being driven by direct-connected motors.

Management Session

At a public session held Tuesday evening at the Hotel Jefferson, eight speakers dealt with the new developments in mechanical engineering that will have a profound influence on the management of industry in the near future. William L. Abbott, of Chicago, President of the Society, presided over the program of the evening which was arranged by the Management Division.

The opening address was made by Robert Thurston Kent, Past-Chairman of the Management Division of the Society. Mr. Kent explained the intimate relation between mechanical engineering and the management of industry, and emphasized the fact that production of goods in greater quantity and with decreasing costs is largely the task of the mechanical engineer. He must provide newer and better ways of using machinery in accomplishing the work of the world and in increasing the well-being of its people.

The speakers in this symposium were Dr. F. R. Low on Steam Power, Prof. R. W. Angus on Water Power, Roy V. Wright on Transportation, Harold V. Coes on Budgeting, Cloyd M. Chapman on Standardization, Edwards R. Fish on Research, and Everett O. Eastwood on Finance. Each one traced the effect of the important mechanical developments in the field of the topic assigned to him and their relation to modern industry and its problems of production, sales, and distribution. The effect of the session was to bring those present up to date in the newest developments in all phases of mechanical engineering.

Power Session

The Power Session, under the auspices of the Steam Power Division, was held Tuesday morning, September 28, and was called to order by Chairman F. R. Low.

Three papers were presented, in the following order: (1) Notes

[1] Works Manager, Beach Mfg. Co., Montrose, Pa. Assoc.-Mem. A.S.M.E.
[2] Machinery Methods, Inc., New York, N. Y.
[3] Oliver Machinery Co., Grand Rapids, Mich.

on the Opportunity of the Engineer in Industry, by Arthur Scrivenor;[4] (2) Interconnection in Virginia and North Carolina, by William C. Bell;[5] and (3) The Design of High-Pressure Industrial Power Plants, by R. S. Baynton.[6]

Mr. Scrivenor's paper touched upon the many opportunities for engineering in the power plant, leaving to the engineer the development of the ideas suggested. Some of the opportunities mentioned were the investigation of new methods and equipment; checking present conditions and advising manager; the planning of improvements; devising methods for reducing operating costs; study of labor conditions, and devising ways of getting maximum results at all times. Both the paper by Mr. Bell and that by Mr. Baynton appear in the October, 1926, issue of Mechanical Engineering.

A more complete treatment of the discussion on these two papers will appear in an early issue of Mechanical Engineering.

Session on Education and Training for the Industries

The Session on Education and Training for the Industries was called to order by Prof. A. F. MacConochie on Wednesday morning, September 29. The papers dealing with apprenticeship and the science of foremanship were procured by the Committee on Education and Training for the Industries.

The first paper, on Apprenticeship, by C. F. Bailey, appears in this issue of Mechanical Engineering. The second paper, by B. H. Van Oot, on Science of Foremanship, will appear in a subsequent issue.

The discussion centered about the importance of careful selection of boys for apprentice courses, coupled with necessary supervision and instruction, which results in the education of skilled mechanics in many ways superior to the average mechanic.

Fuel Conservation in the U. S. Merchant Marine Fleet

Prof. H. L. Seward's paper, which revealed the Progress in Fuel Conservation in the United States Government Merchant Marine Fleet, was presented on Thursday, September 30, on board the *Southland* while on the trip between Norfolk and Hampton. The party gathered on the saloon deck of the boat and spent an interesting hour listening to Professor Seward's presentation and the discussion thereon. The paper appeared in the October issue of Mechanical Engineering, and the discussion with the author's closure will appear in the December issue. President W. L. Abbott presided at this session.

Management Week, 1926

A Statement by Henry S. Dennison, Honorary Chairman

The substantial progress made in the past six years by American business can well be symbolized by the rise in the wage index, from 199 to 220, and the fall in the price index, from 226 to 150. Closer scrutiny approves the symbol, and discloses too the breadth of the field in which progress in waste elimination has been made.

The Unemployment Conference of 1921 brought the reality of the cycle home to thousands of business men, each of whom in his own way has since then played his game with somewhat more foresight and care. Each year has afforded him increasingly accurate and significant statistical guidance. A surer touch is evident—a growing use of budgetary planning, a growing respect for reasoned foresight.

The Committee on Waste in Industry in 1921 gave spur to manufacturing efficiency; the Distribution Conference of 1925 cleared the way for progress in distributing efficiency. We are ready now for self-criticism of distribution methods, no longer defensively believing that those we are using are the best possible.

These conferences, and the growing health of trade associations and of joint research, mark a change in the traditions of management which will be counted by our grandsons most to our credit of any since the War—namely, the opening of the minds of those charged with management to receive information from others and exchange information with them.

The Distribution Conference set before us an ideal of controlled merchandising, of scientific merchandising, a long first step toward which is the simplification movement the Department of Commerce has inspired. When varieties numbered in thousands are reduced to hundreds and hundreds to dozens, not only are manufacturing and carrying costs reduced, but a new necessity and a new incentive for scientific merchandising are created. For simplified lines must be selected more on their merits than on their superficial appeal, market analyses are more valuable and more possible, and scientific open price making is encouraged.

Advertising can be a source of tremendous waste or a means of reducing selling cost. The past few years have seen real progress in studying the practical effects of advertising and in eliminating the more wasteful sorts.

In a similar detached spirit a study of the work of salesmen and saleswomen has been begun by pioneers, and a few first steps in better time scheduling and better training have been taken.

In manufacturing, advances in technology have for many years been conspicuous; but even more important, because of double service, have been our recent advances in good-will. The last two years have brought to both employer and employed a gain in mutual confidence and respect which can, if we will have it so, lead to new planes of possibility of satisfaction and efficiency. We have today the best chance in our history that management and labor will find the terms upon which they can work together.

In all this we have barely just begun. Before us lies much greater progress. For with every increase in complexity or extent in modern life new types of waste appear, and along with them new chances for discovery. We shall not only find new sources of materials, as we found chrome in Montana, but also new and more effective ways of using old materials. Research and testing laboratories are growing, but still some thousands of concerns have yet to realize that every pound of everything they use is "chemical" in nature. In merchandising, selling, and finance the scientific method of analysis and induction as a base for common sense will prove of steadily widening value. Not very long ago production was a handicraft and had its "mysteries," but when science found a place there a new kind of progress started, a compound progress, every step of which showed up still greater possibilities on ahead. A century of experience in bettering our methods of production has been too short to bring us to the end of opportunity. A century of growth of scientific spirit in our selling, financing, and merchandising is still less likely to discover limits to our ingenuity.

At the meetings of the local committees during "Management Week" an inspiring total of practical accomplishments will be reported. A greater and even more inspiring total would be the lesser savings we have made, have woven into our going practices, and forgotten. For waste elimination is greatest as a sum of little things.

So all concerned in management can help, and feel assured that even though specific savings temporarily profit few, before long in this dynamic business world true savings all find their ways to the service of society.

Our truest progress in the last few years has been along coöperative lines, by openness and frankness. This has induced analysis and a scrupulous care for accuracy, and this in turn a growing skill in foresight and in planning. These are the conditions which have preceded the birth of all the great professions. They hold the promise, if we will heed them, that to take part in business management may some day become as high a service as the best traditions of medicine and teaching demand; that we may soon regard the lessening of waste as doctors now regard the mitigation of disease; that we can make of management a great profession, bringing to man material gains—and spiritual gains immeasurably outweighing them.

[4] Consulting Industrial and Mechanical Engineer, Richmond, Va. Mem. A.S.M.E.

[5] Chief Engineer and General Manager, Virginia Electric and Power Co., Richmond, Va., Mem. A.S.M.E.

[6] The Chesapeake Corporation, West Point, Va.

A.S.M.E. Machine-Shop Practice Session at the A.S.S.T. Convention

MACHINE-shop problems were discussed under particularly favorable circumstances during the annual convention and exhibit of the American Society for Steel Treating in Chicago. Record-breaking attendance favored the Steel and Machinery Exhibit at the Municipal Pier from September 20 to 25, and the 80,000 square feet of floor space were filled with an extraordinarily interesting collection of steel-making, steel-treating, and steel-working equipment. The machine-tool section of the exhibit presented a complete picture of the latest in high-production machine-shop equipment, which together with the many worth-while inspection trips to well-known plants in the Chicago district furnished a desirable background to the Machine Shop Sessions.

The A.S.M.E. program was under the supervision of the Chicago Section and the Machine Shop Practice Division and was presented at the Drake Hotel on the afternoon of September 23. Frank W. Curtis, western editor of the *American Machinist*, presided, and the speakers were: Herbert K. Keever, production manager, McDonald Machine Co., Chicago; E. D. Hall, superintendent of Inspection Development, Western Electric Co., Chicago; Eugene C. Clarke, vice-president and general manager, Chambersburg Engineering Co., Chambersburg, Pa.; and Hugo Diemer, Director of Industrial Development of the La Salle Extension University, Chicago.

Mr. Keever spoke upon Possibilities of Standardizing Design Details in Plants Manufacturing Special Machinery. In attacking this subject he defined a special machine as really an arrangement of standard mechanisms designed to accomplish definite performance such as wrapping a particular sort of package. Looking at the problem from this viewpoint he showed that many sub-assemblies (themselves made up of standardized elements) can be built in quantities and kept in stock to be quickly assembled as and when occasion requires. He cited several well-known machines generally considered special but which are special only in regard to rather superficial details needed to fit them to a particular purpose.

In the lively discussion of Mr. Keever's paper following its presentation, Mr. Cole called attention to the recent appearance of details for jigs and fixtures upon this plan, and he suggested how these may be used to advantage. Mr. Cole took the opportunity to make a strong plea for better coöperation between the engineering department and the shop in the development and execution of new designs. Mr. Diemer spoke from personal experience regarding simplification and standardization in the machine shop, and predicted much wider application of these principles.

Mr. Hall's subject was Modern Development in Inspection Methods. He covered thoroughly with the help of many slides and actual pieces of apparatus the remarkable device which is in use at the Hawthorne works of his company by which close inspection of the product is enabled to keep pace with its mass production without resorting to any undue number of highly skilled inspectors. This paper will be published in an early issue of MECHANICAL ENGINEERING.

During the discussion of this paper Mr. Johnson spoke of the possibility of having an automatic inspection machine on the floor with the production machines so that work would be inspected as turned out and under the immediate attention of the operators who are responsible for its accuracy. Mr. Diemer told of pioneer work in automatic inspection during the World War, at which time the ordinary methods of inspecting cartridges were broken down completely by the vast quantities involved. The result was that automatic machines were evolved which gave 100 per cent inspection and still held pace with production. Only a few skilled inspectors were then required, their duties being to check the inspecting machines from time to time and in case of too frequent rejections of work to trace the inaccuracies back to their sources and see that proper steps were taken for correction.

The next paper was by Mr. Clarke and covered Drop-Forge Hammer Anvils. Mr. Clarke stated that American drop-forging practice has advanced far beyond that of Europe, principally because of the tremendous demands of the automotive industry. He cited as the greatest development that of multi-impression dies which under a single hammer will rough out, form, and finish a forging in a few blows.

Mr. Clarke then showed how the development of forging practice has placed steadily increasing strains upon the anvils, until their design has become a major problem in the construction of dependable drop hammers. He began by showing a slide of an ancient pair of Grecian coining dies shaped something like a notary public's stamp.

Next came, centuries later, the system of keying the lower die to the anvil with the upper die guided above it and sledged by hand hammers. In this case the anvil was subjected to lateral thrust and expansion through heat. From this developed the drop hammer with upper die attached and with guides affixed to the anvil, subjecting it to additional side thrusts.

Early drop hammers had meager lateral support for their anvils. As blows were increased, as the steam hammer came into general use, and as off-center work in multi-depression dies became common, the demands upon anvils became more and more severe, and the history of hammer design is also a history of anvil improvement.

The prime considerations in the design of a modern anvil were innumerated by Mr. Clarke as mass, impact, side thrust, splitting action due to cap key and temperature changes, internal stresses, manufacturing facilities, and foundations. He explained how each of these considerations is taken care of, stating that it is a primary requirement that the weight of the anvil should be twenty times the falling weight. Many designs were illustrated, including ingenious ways of avoiding breakage, among others laminated construction. The subject of foundations was discussed thoroughly as one of vital importance to the life of the hammer as well as that of the surrounding structures.

Mr. Clarke was followed by Hugo Diemer, who closed the session with a paper on Foremanship Training. Mr. Diemer began by saying that it is generally conceded that the foreman is the man to whom the management have to sell their ideas in connection with production management or personal management before these ideas or plans can become thoroughly effective. Foremanship training should aim to prepare the mind of the men to be receptive in this respect, and if it succeeds it is well worth while.

Modern organization systems have taken away from foremen many of their old-time duties and activities, Mr. Diemer said, but at the same time have given higher responsibilities to take the place of these lesser ones. He is now a bigger man, and on this account his choice and training assumes still greater importance.

Without proper training many foremen become confused by the intricate methods of management and become alienated through the destruction of their self-confidence. The responsibility for better foremanship rests primarily upon the management, and improvement must begin with the management.

Having begun foremanship training the management must back it up and follow it through just as persistently as they do production control and personnel management. Both classes will then face problems with the same spirit.

Under the older method of choosing, training, and handling foremen they were almost wholly excluded from participating in the design, installation, and operation of systems of planning and control. It is now realized that the chief function of a foreman is leadership and that the biggest part of his duties has to do with the human element which is the real cornerstone of industry. He must know men and he must study production methods so that they may be in line with good practice in "human engineering."

Mr. Diemer described the history and progress systematic training along these lines in detail, mentioned several organizations which will coöperate in carrying it out, and gave figures as to cost. Suggestions were made as to preparation of home-study courses, planning of teaching staff, and for holding the interest of the men.

The resulting discussion proved this to be a subject of general interest, and one which is receiving wide attention in industry.

Foundrymen Meet in Detroit

Thirtieth Annual Convention Marked by Large Attendance, Especially from Abroad, a Wealth of Technical Papers, and a Huge Exposition of Foundry Machinery

THE thirtieth annual meeting of the Association was held in Detroit, Mich., at the State Fair Grounds, September 27 to October 1, 1926. The program, besides the more or less usual social functions, comprised a series of papers and an exhibition of machinery and devices of interest to the foundry trade. Many of the papers, notwithstanding their unquestioned value, cannot be reported here, being of specific interest only to foundrymen; however, excerpts from and abstracts of such as are of more or less general interest to mechanical engineers immediately follow.

Foundry Instruction in Technical Schools

Two papers were devoted to the subject of instruction in the foundryman's art. A series of speakers discussed the foundry instruction at Carnegie Institute of Technology, Purdue University, University of Michigan, and University of Illinois. At Purdue University two courses are given—elementary, and advanced, and methods used in the latter were presented by R. E. Wendt in considerable detail. The Purdue course is one for engineering students rather than for apprentices. Apprentice-training results secured by a lecture course and supervision formed the subject of a paper by P. R. Ramp describing the methods used at the works of the Newport News Shipbuilding and Dry Dock Company. There in teaching young men how to mold, methods are simplified and a great deal of time is spent in deciding upon the very best practice before attempting to teach the apprentice boy how to do it. The following may serve as an example. Turbine casings were made in loam for a number of years. It required three weeks and sometimes longer to get one of these molds ready for the oven. Then a flask was built, alterations were made on the pattern, and as a result of the improved method and the enthusiasm of the young men the work was done in three and a half days instead of three weeks.

Steel and Cast Iron as Engineering Materials

A number of papers were presented on the physical properties of cast iron and steel and metallurgical factors affecting them.

W. H. Rother and V. Mazurie presented a paper on the Strength of Cast Iron in Relation to Its Thickness. Cast-iron beams of various thicknesses, they pointed out, do not follow the regular beam formulas as set down for rolled steel, and in order to determine just how cast iron varies with thickness, an investigation was undertaken. It was found that iron of 2.15 per cent silicon content decreased in transverse strength on an average about 6 per cent for each $^{1}/_{2}$-in. increase in thickness between 1 in. and 3 in. An iron of 1.70 per cent silicon content, with a steel addition of 15 per cent, decreased 4 per cent for each $^{1}/_{2}$-in. increase in thickness between 1 in. and 3 in. An iron of 1.20 per cent silicon content, with a steel addition of 25 per cent, had a decrease of 3.3 per cent for each $^{1}/_{2}$-in. increase in thickness between 1 in. and 3 in. The percentage decrease in transverse strength was found to be greater for square bars than for round bars. The percentage of decrease in Brinell hardness with increasing thickness was found to be practically the same as the percentage decrease in transverse strength. It appears that the decrease in strength tends to follow the silicon content, as high-silicon irons tend to show a greater decrease than low-silicon irons containing steel. In practically all properties semi-steel proved best. Before any factors which will aid in the calculation of the strength of iron castings can be determined, the authors conclude, much research work will be necessary.

Heat- and Scale-Resisting Cast Irons formed the subject of a paper by Oliver Smalley, who discussed the place of semi-steel and advance in foundry processes, both by varying the rate of cooling so as to control the deposition of the graphite and by the use of special metals, alloys, or chemical graphitizers, the aim of which is to control and cut down the rate of cooling during solidification and thereby obviate the disadvantages of special casting arrangements and the use of hard-baked molds. The paper described tests on specially cast slabs from cupola-melted iron.

E. Piwowarsky, in a paper presented on behalf of the Association of German Foundries, told of the developments of the quality of gray cast iron in Germany during the last few years, in particular in connection with the so-called "pearlite" cast iron. Among other things, he stated that the rate of cooling being the same, an increase in refining of the graphite takes place as superheating of cast iron is increased. The subject of the relation between chemical composition and superheating was also discussed. The author also referred to the mechanical shaking of melted iron, of which mention was recently made in trade papers. "This influence of the refining of graphite," he said, "which is so favorable to the quality of the cast iron, and also that of the decreasing the gas as a result of the treatment of the heat at high temperatures (abnormally high), should after the foregoing be expected also from a treatment in the vacuum at somewhat lower temperatures (about 1400 to 1500 deg. cent.) or from a sufficient mechanical shaking of the cast-iron heat, as has been done years ago for ingot iron and steel. K. Irresberger, by use of a mechanical shaking in a forehearth (by an eccentric motor fitted for oscillating the forehearth), obtained very good mechanical qualities in cupola iron. In order to make the removal of the slag particles still more efficient, the author has proposed a rotating movement of the forehearth or of the casting ladle, whereby the specifically lighter, non-metallic substances are forced inward because of the centrifugal action and moved upward, to become slag."

The German process for producing high-grade cast iron was also referred to. Only the high spots of the paper are mentioned in the above abstract.

J. T. MacKenzie told about tests to determine the influence of phosphorus on cast iron. His paper gives the analysis, bending curves, drop test, and Brinell hardness on a large number of irons cast in 2 × 1 × 24-in. bars. Phosphorus is shown to lower the strength and resilience, to increase the Brinell hardness, and to stiffen the bar slightly. Some data are given to show that in some cases phosphorus, by promoting fluidity and hence soundness of the casting, actually helps to make a stronger casting.

R. R. Kennedy and G. J. Oswald investigated the effects of various alloys on the growth of cast iron under repeated heatings. In an attempt to develop a gray iron which would have a slow rate of growth under repeated heatings, various alloys were added to iron in the ladle. The addition of phosphorus and deoxidation with titanium were found to have the greatest effect in retarding growth.

The whole subject of the effect of phosphorus and sulphur in steel was broadly covered in a report of the A.F.A. representative, Maj. R. A. Bull. As to sulphur the report is negative, the joint committee having decided definitely not to conduct any sulphur tests on the product of the steel foundry. An effort will be made to ascertain the attitude of the A.F.A. on the matter of determining the effect of phosphorus in steel castings.

Manganese in Cast Steels formed the subject of a paper by John Howe Hull. The author feels that the results of these tests fully justify the opinion he has long held that heat-treated cast steels containing from 0.20 per cent to 0.30 per cent carbon, and manganese from 1 per cent to 2 per cent, possess a remarkable combination of properties that makes them of the greatest value for severe service in machine parts; indeed, the tests are but a confirmation and explanation of the remarkable record made by castings of this class which have been manufactured during the seventeen years since they were first introduced. In the same investigation it was found that vanadium raised the yield point and the tensile strength of the steel to a considerable extent, but the extension, reduction of area, and bend were decreased by vanadium. The high-manganese steel with a plain annealing, however, gives a better tensile test and bend than the carbon-vanadium steel in the same

condition, though a lower Charpy value, and when "quenched and drawn back" the high-manganese steel gives nearly four times the shock toughness of the carbon-vanadium steel plain annealed, with better tensile figures and bends. Even when "quenched and drawn back" the carbon-vanadium steel gives but half the shock toughness of the high-manganese steel in the same condition, and not as high extension, reduction of area, and bend. It is also worth noting that the Charpy value for the carbon-vanadium steel with a plain anneal is not as high as that of the plain carbon steels of equivalent carbon.

Malleable cast iron formed the subject of two papers. In the paper presented on the behalf of the Czecho-Slovakian Foundrymen's Association by O. Quadrat and J. Koritta, tests are reported made with the purpose of examining the influence of the temper carbon on the physical properties of gray-heart malleable castings.

In another paper H. A. Schwartz (Mem. A.S.M.E., National Malleable and Steel Castings Co.) attempts to answer the question as to what may be required of malleable castings. He believes that chemical specifications are generally meaningless and cites instances where they do harm. It is the physical properties which in his estimation are particularly important. Machinability requirements are briefly discussed, as well as possible cases of increased resistance to cutting.

A major commercial problem is to deal equitably with the condition existing when there are delivered to the consumer a great number of satisfactory castings through which a few of inferior machinability are scattered without any means of finding the latter. A very few hard castings will entirely disorganize a day's production schedule by the breaking of tools. To this extent they work an injury on the user out of all proportion to their number. On the other hand, it is distinctly unfair to the producer to return to him a carload of castings which may be all good except one or two which have given trouble.

It is under such circumstances as these that test-lug inspection by the consumer will work wonders by enabling him to check the castings before delivery to the machines and relieving the producer from the sole responsibility of seeing that not a single poor casting ever goes on with those which are acceptable.

The Resistance of Malleable Iron to Repeated Impact Stresses and Comparison of Strength of Machined and Unmachined Malleable Castings, was the title of a paper describing tests made under the direction of Enrique Touceda.

In a paper entitled A Shearing Test for Gray Cast Iron, G. K. Elliot discussed the use of the Frémont machine for testing cast iron. The operation and the construction of the machine are first taken up. Tests of bars and flanged pipe fittings were made. The test results secured by the use of the Frémont machine are compared to the usual transverse and tensile test results. A modification of the machine was constructed to give double and shearing and to overcome some of the disadvantages of the original apparatus. Test results secured by W. Rother, using the same Frémont machine, are given in the concluding section of the paper.

A further investigation of the influence of metalloids on cast iron is presented by John Shaw of Sheffield, England, in a paper entitled Some Gray-Iron Problems. The author states as his purpose that he proposes to consider (1) the influence of sulphur and manganese on the structure of cast iron containing ordinary amounts of the other elements, and (2) to deal with the influence of carbon and silicon, in conjunction with the other elements in the structure, and finally (3) the usefulness of various chill tests to the practical man for judging roughly the ultimate structure of his molten metal before casting. He presents several theories which have been advanced concerning the manganese-sulphur balance, and then takes up the influences of furnace temperature on the formation of sulphur and manganese. Further discussion of the form of sulphur in cast iron is given. A study of chilled rolls is used to illustrate the author's contributions. Next he discusses the various views accounting for the differences in loss of depth of chill between test pieces and the results secured in the rolls. The concluding section of the paper deals with effect of the ratio of carbon to silicon or structure as judged by the chill test. Mr. Shaw's remarks on the sulphur question are particularly enlightening. "Starting with sulphur," he says, "it is noted that not long ago nearly every ill in the foundry was attributed to this element. Today there is a danger of rushing to the other extreme. To quote only one authority, 'A summary of most recent work goes to prove that sulphur in commercial cast irons, in the presence of sufficient manganese, exists almost wholly as the sulphide of manganese. In this form it is practically without influence on the structure and properties of cast iron.' Now push this statement to its logical conclusion. It means, if it means anything, that it does not matter what sulphur your scrap contains. It does not matter if you use a high-sulphur coke (for there are good low-ash, good-structure cokes with high sulphur), for you have only to raise the manganese content of your pig iron, and no ill effects will follow. You try this theory out on thin work and I am afraid you will be sorry."

He discusses next the so-called manganese-sulphur balance and the relations generally between manganese and sulphur in steel. After a careful investigation of the subject he adopts the views of Röhl and Law, who to all practical purposes tell how little we know of the way sulphur occurs in iron containing manganese. He believes that a mixed sulphide is usually found in ordinary foundry iron. Acceptance of this view would explain the influence of small amounts of manganese in cupola metal, for not only would it reduce

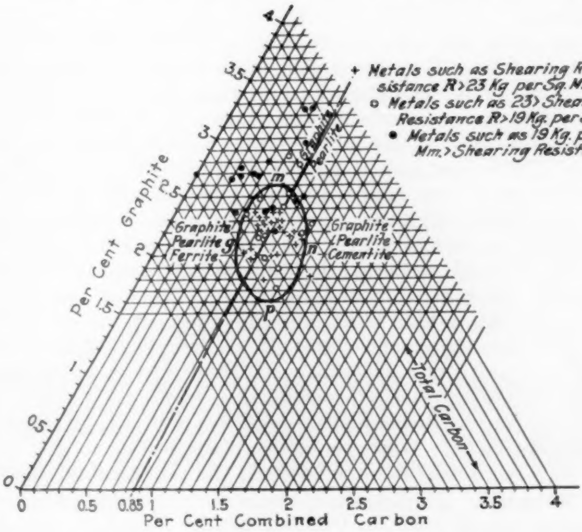

FIG. 1 CAST IRONS PLOTTED ACCORDING TO QUALITY (PORTEVIN'S DIAGRAM)

the manganese by less than one-half to counteract the influence of sulphur, but would bring its melting point of 1365 deg. cent. well within cupola temperatures.

TESTING CAST IRON

A French view on testing cast iron was presented by Auguste-Eugene Le Thomas of Indret, France, on behalf of the Foundry Technical Association of France. When at home the author is engineer in charge of laboratory and metallurgical departments of the Indret Works of the French Navy. The methods of testing which he describes have been invented principally by Frémont and Portevin. For purposes of tests various grades of cast iron are classified as follows: (1) Those with a shearing strength of over 23 kg. per sq. mm. (32,713 lb. per sq. in.), and which are designated in the graph, Fig. 1, by crosses. (2) Those with a shearing strength of between 19 and 23 kg. per sq. mm. (27,024 to 32,713 lb. per sq. in.), and which are denoted by small circles. (3) Irons with a shearing strength of less than 19 kg. (27,024 lb.) and which are indicated by dots.

Referring to Fig. 1, it will be seen that cast irons of very good quality are assembled about the point defined by the coördinates, total carbon 3 per cent, combined carbon 0.80 per cent, while inversely the mediocre metals have their figurative points at some distance from the same center. Conversely, after the analysis of the metal has been made it may be said that a metal the figurative point of which marked on the triangular diagram is noticeably distinct from the small zone, is likely to turn out of indifferent quality.

Now the metals here discussed are not in any sense alloys in a

state of equilibrium, and therefore their properties ought not to be considered from too absolute a point of view. Moreover, the diagram does not take into consideration certain influences, in particular those of the manganese, silicon, and phosphorus, which, it is quite certain, modify—other things being equal—certain properties, either mechanical or physico-chemical. On this latter point the author thinks it may be laid down—and this is the result of several hundred tests—that the limit of the ferrite and cementite spheres is displaced toward the left when certain elements are added to the iron and to the carbon. The result of which is, for example, that a metal containing 3 per cent of total carbon, 0.73 per cent of combined carbon, and little silicon and manganese, will be hypoeutectoid, as shown in Fig. 1. That is, it will show under the microscope clusters of ferrite; while a metal containing 3 per cent of total carbon, 0.73 per cent of combined carbon (2 per cent approximately) of silicon, and 0.50 per cent (approximately) of manganese, will be hypereutectoid; that is, it will show under the microscope elements of cementite.

In any case it is beyond question that the diagram submitted by M. Portevin is of great interest from the practical point of view (this is proved by the example cited), and that it may be of considerable service.

Among others, the following tests are described. The shearing test used was devised by Frémont as a reception test for the finished casting. Frémont's studies on the subject of the shearing of steels led him to the conclusion that there is a close relationship between rupture by shearing or by punching and the action of simple fracture. The author uses at present the small Frémont machine which uses smaller test pieces, measuring 5 × 5 mm. (0.197 in.) or 5.65 mm. (0.222 in.) round (section 25 sq. mm. = 0.3875 sq. in.). This machine consists of a lever movable about a sharp edge, the longer arm of which supports a movable weight, while the smaller arm exercises pressure, through a hard blade, upon the test piece, which is sunk into a hard block and into a recess provided in the blade. The slow movement of the weight along the longer arm is obtained by means of a suitable mechanical device; while this movement is taking place a pencil carried by a small suspensory arrangement traces a diagram on a fixed sheet of paper. When the test piece breaks—the resistance point of the section to shearing having been reached—the lever falls and the pencil marks clearly the end of the test. The horizontal length of the diagram, by means of a suitably simple formula, then enables the shearing resistance of the test piece to be registered.

This small machine is extremely convenient in service. Its reasonable price makes it suitable for use in the smallest foundries. It is supplemented by a small apparatus for taking test pieces, consisting of a bit and an eccentric system devised for taking round test pieces.

It is possible, as Thyssen has done, to adapt to this small machine a cylinder which will register accurately the shearing deformations of the bar and the loads. The experimenters did not do this, contenting themselves with measuring the breaking load under shear, while depending upon the static bending test, if necessary, for any particulars required regarding the (restricted) elongation capacity of the cast iron. To sum up, it was decided to regard the shearing test as the typical test—the simple test which should always be carried out immediately the castings reach a certain importance.

The test is particularly suitable for this purpose. The possibility of repeating the test on the same test piece guarantees great experimental accuracy; the very simplicity of registration afforded by the machine insures exceptional uniformity; the construction of the apparatus makes it almost impossible for it to be put out of adjustment; and the cost of making the tests is most moderate.

The compression test has the advantage of being accurate, but has the disadvantage in that the breaking load by compression is very high, which means that a large machine is necessary. Because of this the method of classifying cast iron by compression test has been abandoned at the author's laboratory. On the other hand, the static bending test is considered to be valuable and Frémont has invented a machine which enables small test pieces, which can easily be taken from any portion of the casting to be examined, to be tested with accuracy. The test piece, which is a prism of 8 mm. × 10 mm. × 35 mm. (0.315 × 0.394 × 1.378 in.), is placed in two supports 30 mm. (1.181 in.) apart. A knife, actuated by a spring pressed by a screw, exercises pressure upon the middle of the test piece. The screw itself is subjected to longitudinal motion by means of a handwheel. The effect of the intermediate spring is to transmit the stress gradually and without shock, for a very slight live force is sufficient to break the best test piece. When the test piece breaks with a deflection which is a fraction of a millimeter, the bend of the spring generally amounts to from 10 to 20 millimeters, which corresponds to several turns of the handwheel.

A device designed for the purpose enables a diagram of large size to be traced automatically, on which are recorded the successive indices of the load and deflection. A large number of tests has enabled him to lay it down that "cast iron has an elastic bending capacity which is very variable and, generally, greater in proportion as its breaking strength is less. Under the same stress, two test pieces of the same dimensions, but of different strengths, will show different deflections; that of lesser strength will bend more, and thus it will have a greater bending capacity. It will therefore require, to produce this flexion, a greater amount of work, since the deflection will be greater, and this difference may vary from one to three-fold. This is a general law, for, although there may occasionally be discrepancies, they are neither sufficiently numerous nor, particularly, are they sufficiently important to invalidate this principle. This elastic bending capacity, inversely proportional to the strength of the metal, explains the failure of the tensile tests of good metal." (Frémont, op. cit.)

As already stated, for several years the experimenters employed the Frémont bending test on the metals used in the production of parts of marine engines. The static bending test bar should be taken from a boss retained on the casting when poured, unless special circumstances permit of its being taken from the very center of the casting, which is rarely the case. As regards machining, it will be observed that as lathe work is generally more convenient and less costly than planing (for example, with the shaping machine), the static bending bar is more expensive than the compression bar. The static bending test, however, has one advantage: namely, it enables the elasticity of the metal to be conveniently estimated.

Owing to the nature of the information which it yields, the static bending test is, in the experimenters' opinion, the most desirable—that which is best suited for indicating the quality of the metal.

The ball test has been used, particularly for semi-steel shells. Investigations are of course also used, and these have shown the decided influence of the various structural elements on the physical properties of the metal. In fact, in the field of machine castings the authors consider this method as one of the most rapid, inexpensive, uniform, and accurate, once a certain amount of practice has been acquired. It reveals to most minute variations of manufacture and makes it possible to foretell with a great degree of accuracy the results of the mechanical tests. Chemical analyses are also made, but chemical composition is not considered as an accurate standard, and as a rule merely serves the purpose of an approximate guide as to the probable strength of the metal. An interesting part of the paper is the section dealing with the relation between the results given by various methods of testing machine castings. Here tests have shown a certain parallelism between the results of different methods of testing, and the author cites the following formulas suggested by Portevin and claimed to unite approximately the various physical properties: Compressive strength = 2.5 × tensile strength + 18 (small number of tests); Tensile strength = $0.2\,\Delta - 13$ (few tests, but in marked agreement);

Compressive strength $= \dfrac{\Delta}{2} - 5$ (large number of tests).

These three equations combining three variables should be such that one can be algebraically deduced from the other two. This is not the case, and the experimenters therefore at once see how they ought to regard these formulas, or others, such as the following, which result from their own tests:

$$\text{Compressive strength} = \frac{3}{5}\,\Delta - 54$$

$$\text{Shearing strength} = \frac{\Delta}{5} - 19$$

Compressive strength = 3 × shearing strength + 3
Tensile strength = 0.9 × shearing strength — 1.

The French Navy specification developed on the basis of the information contained here is cited by the author. It applies to machine castings which must be very specially guaranteed, owing to their use in marine engines. A bibliography of French articles on the subject forms an appendix to the paper.

Principles and Chief Applications of Dilatometric Analysis of Materials was the title of an exchange paper on behalf of the Foundry Technical Association of France, presented by A. Portevin and P. Chevenard. In the dilatometric method use is made of the linear expansion of a metal due to heating. It presents the advantage over the electric and magnetic methods of being less sensitive to secondary actions: presence of impurities, thermal history, etc. In the differential recording dilatometers the diagrams are drawn photographically or by a mechanical process. The differential dilatometer may be used not only for the thermal analysis of materials but for the measurement of their coefficient of expansion at any temperature below 1100 to 1200 deg. cent. The main value of dilatometric analysis appears, however, to be in the study of different types of transformations in metals, several of which the authors discuss.

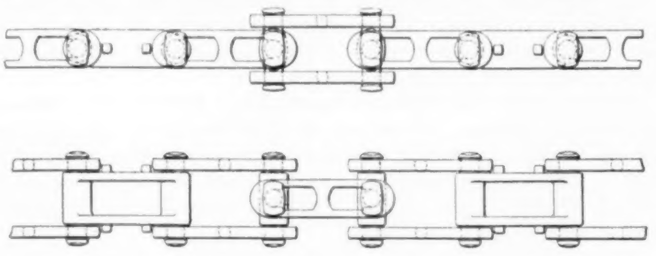

FIG. 2 OPEN-LINK UNIVERSAL-JOINT DROP-FORGED CHAIN

The following are some of the conclusions arrived at by the authors:

Dilatometric analysis possesses, like chemical analysis, a double aspect.

(*a*) *Qualitative Analysis.* Specific anomalies at definite temperatures, like those of cementite, mark the presence of phases: definite compounds or solid solutions, the chemical composition of which is known. Examples: complex cementites and constituents of meteoric irons.

But although chemical analysis indicates only the total composition of an aggregate, dilatometric analysis gives information about the nature of the components and so constitutes a process of *proximate analysis.*

(*b*) *Quantitative Analysis.* The magnitude of the anomalies which have been mentioned furnishes a process of *quantitative* estimation of the constituent whose presence is thus revealed: estimation of the amount of free cementite contained in a steel after various treatments. Furthermore, Tammann's method for the quantitative investigation of invariant, isothermal reactions can be transposed to dilatometry. It suffices to study as a function of concentrations, the magnitude of the dilatometric phenomenon corresponding to the reaction, to find by extrapolation the concentrations of the reacting phases.

This generalization can be extended to all the physical methods, which offer the advantage over the thermal method of not requiring corrections of the magnitude to take account of variations in the rate of cooling; from this general method of physico-thermal analsis, it is expected interesting results for the establishment and the revision of equilibrium diagrams.

Dilatometric analysis is suited not only to massive test pieces obtained by casting or by machining, but to rods prepared by the agglomeration of powdered substances. By this method Braesco has studied the specific irregularities of different varieties of silica, and Chaudron the thermal transformations of the iron oxides. It is thus possible to analyze the industrial reactions that occur in a solid medium: calcining, cementation, etc.

Finally, independent of thermal analysis, the differential dilatometer enables the expansibility of materials to be determined over a great temperature interval. This measurement, of evident scientific importance, affects also numerous industrial problems: the selection of the materials forming the parts of heat engines or refrigerating machines, glass equipment in the manufacture of optical instruments and artistic glassware, choice of electrodes for welding to glass, foundry enamels, etc.

THE EXPOSITION OF FOUNDRY MACHINERY

The exposition held in connection with the meeting of the American Foundrymen's Association was housed in three big buildings at the Fair Grounds. Because of the large amount of floor space available there was no crowding of exhibits and plenty of opportunity to inspect the machinery and material shown comfortably and unhurriedly. The importance of this factor is not as often realized in machinery exhibits as it should be. A number of exhibits were in actual operation, particularly trade foundry machinery. One concern even went so far as to show a commercial-size electric furnace actually melting metals.

In the account which follows no attempt is made to give a comprehensive description of everything shown. Many of the exhibits are quite well known to engineers; in fact, comparatively few were radically new. The majority of the exhibits, as is natural, were of interest to foundrymen exclusively, and descriptions of them will be found in special foundry trade papers.

The National Brake and Electric Co. (division of Westinghouse Air Brake Co., Milwaukee, Wis.), showed a 150-ton hydraulic press in which are incorporated several new features. The most important of these are the new four-way automatic valve, an adjustable safety valve for the pump, and an automatic distance safety valve located in the ram head of the press. The installation consists of a motor, small pump, and press proper, no accumulator being used. One lever operates the whole machine. It is moved to the extreme left for the down stroke, to the extreme right for the up stroke, and in the center or neutral position stops the ram at any point in the up or down stroke. The pressure is controlled by the safety valve, and the stroke of the ram by the distance safety valve.

FIG. 3 CONVEYOR-CHAIN TYPE SHOWN IN FIG. 1 BUT WITH PUSHER SHOE

The Rollway Bearing Co., Syracuse, N. Y., exhibited the Rollway bearings, an interesting characteristic of which is that no housings or cages for balls are used. According to an article by A. G. Place in *Industrial Engineering* for June, 1926, this type of bearing was installed early in 1918 in the East Youngstown plant of the Youngstown Sheet and Tube Co. and consisted of two sets in two mill-type motors on the bridge motion of a hot-metal crane in a mixer building of the bessemer plant. This is one of the worst locations in the mill for electrical equipment, because when hot iron from the blast furnace is poured into the mixers, flecks of graphite and iron float around in the air and cover everything in the building. This and other installations are said to have given good satisfaction.

Drop-forged chains of several types were shown by at least two concerns. The Anthracite Chain and Engineering Co., of Hazleton, Pa., showed an interesting open-link type, Fig. 2. This consists of two parts, center and side link, and to assemble them all that is necessary is to place them at right angles and put them together, no pins, cutters, or rivets being used. As shown in the figure, a connecting piece may be such as to provide a universal joint effect. For conveyor chains, Fig. 3, a pusher is provided which remains in the position as shown when conveying, but pivots when going over the sprocket and acts as a shoe on the return line, preventing the chain from dragging. A somewhat similar design of rivetless chain under the name of "Keystone" was shown by the Wilmot Engineering Co., Hazleton, Pa. This uses a pin in addition to the side links. It is claimed that the presence of the pin does not affect the safety of the chain. In order to remove the

pin the chain has to be placed in a certain position, and since it is impossible for any part of the chain to assume this position of itself, a chain once assembled is absolutely locked and may be handled in shipping or erecting without danger of any part becoming detached.

A number of measuring instruments were shown, such as pyrometers, etc. The majority of these are of well-known types and need no description. The Pyro-lance, which is a newer device, consists of a bar with a millivoltmeter or milliammeter reading directly in degrees fahrenheit, and a tube at the end of which is hooked on a thermoelement which can be tilted to any desired angle. This thermocouple is inserted into the metal directly without any protecting tube. The instrument weighs but little and is convenient to use. It is suitable apparently for alloys melting not higher than about 2100 deg., but would not do for steel.

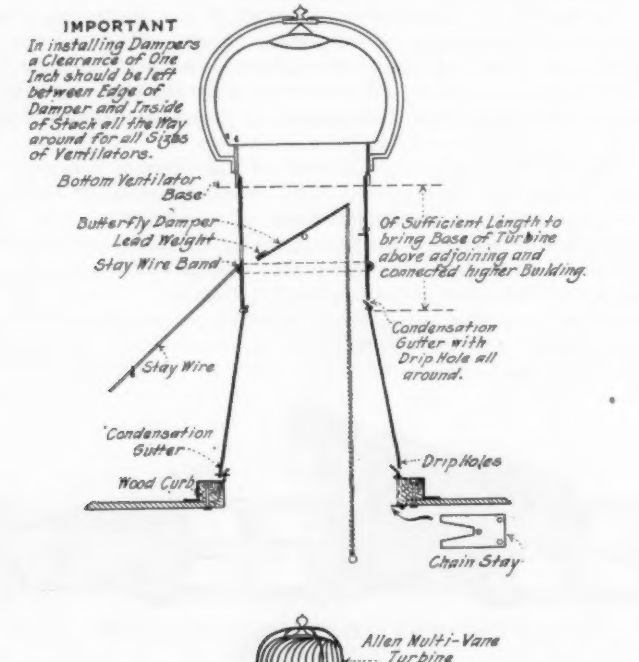

Fig. 4 Allen Multi-Vane Turbine Ventilator (Top: Typical Installation Sketch; Bottom: General Design of Device.)

Another interesting instrument is the McIlvane moisture meter to measure the relative moisture of molding sand. The operation of the device is extremely simple. The meter consists of a handle carrying the device and a bar. The lower end of this latter is inserted into the sand and the relative moisture is instantly registered on the dial at the top of the instrument. The details of operation could not be obtained. It is only stated that it operates on small flashlight batteries.

In the field of welding the Alexander Milburn Co., Baltimore, Md., exhibited a welding apparatus in which illuminating gas is used instead of acetylene. This has been already described by F. O. Wilson, Jr., in the *General Electric Review*, vol. 29, no. 6, June, 1926, pp. 553–555. Tests made at the Schenectady works of the General Electric Co. are said to show that illuminating gas is much more economical in machine cutting than either hydrogen or acetylene. In hand cutting the nature of the work determines the gas used for preheating, and the only particular class of work in which acetylene is superior to illuminating gas is said to be rivet cutting or similar operations where the preheating time is an appreciable share of the total time required for the operation.

A number of speed reducers were exhibited. None of them, however, afforded sufficient data to give a basis of comparison. An interesting device of this character is the Reeves drive made by the Reeves Pulley Co., Detroit, Mich. This consists of a high-speed motor mounted above the variable-speed transmission and connected to the constant-speed shaft of the latter by silent chain or gear. A range of 16 to 1 is claimed for it.

The Jones speed reducer made by the W. A. Jones Foundry and Machine Co., Chicago, is claimed to be able to give reduction ratios as high as 200 to 1. In this device the drive is on a balanced straight line, driving and driven shafts being axially concentric and having the same direction of rotation.

In the Millerhurst speed reducer either silent chains or herringbone gears are used as the intermediary members. The herringbone-gear-type reducer has standard ratios of 15, 25, 54, and 132 to 1, and the low-speed shaft has capacities up to 10,000 in-lb. torque and 35,000 lb. chain pull.

The exhibit of the Michigan Smelting and Refining Co., Detroit, showed the advance for the art of brass forging in this country. These forgings are made on special presses under a pressure of 300 to 1000 tons and are said to have a tensile strength of approximately 60,000 lb. per sq. in. Samples shown at the exposition had a very clean appearance.

A rather large device was exhibited in the ventilation field, namely, the Allen multi-vane turbine ventilator. The typical installation sketch of this ventilator is shown in the upper part of Fig. 4, while the ventilator itself is shown in the lower part of the same figure.

The subject of defects in steel castings was discussed from two different points of view, R. S. Munson dealing with defects in the foundry, and J. M. Sampson with those discovered after shipment from the foundry. Speaking generally, the cause of defects in steel castings in the foundry, according to R. S. Munson, can be placed under three main heads: (1) design and pattern equipment; (2) molding and core-shop methods; (3) melting and pouring conditions. The first of these is the only one of direct interest to mechanical engineers. In the matter of design, especially in the jobbing foundry, the steel foundryman is often the unwilling and unhappy victim, since most of the castings he makes are designed by his customers, and in many cases the engineer in his effort to limit weight or decrease assembly costs designs a casting not consistent with good steel-foundry practice. Most steel foundrymen could cite instances from their own experience where, after suffering heavy losses in the foundry from castings of this character, they have made changes in the original design, in order to conform to good steel-foundry practice, by which they have been able to produce satisfactory castings without great loss from defects. In order to reduce the defects from this cause the steel foundry should insist that its customer's engineers consult with them as to castings of new or intricate design. By doing this it is possible to work out the problems beforehand satisfactorily and save losses to the foundry and vexatious delays to the customers.

In Mr. Sampson's paper an analysis is made of the discounts in the steel foundry, and particularly of the rejections and salvaging work in the machine shops. He hopes that all steel foundrymen can come to a better realization of the very great losses incurred in machine shops, due to not only hidden defects but to those that should have been discovered and remedied prior to shipment.

An interesting instance how a rather unusual situation was handled is described in a paper on Melting All-Steel Charges in a Cupola Furnace by T. F. Jennings. Necessity of disposing of an accumulation of 12,000 tons of miscellaneous steel scrap forced the author into developing a method for melting entire heats of steel in the cupola. No attempt was made to produce a machinable gray iron suitable for the ordinary run of castings made in an iron foundry. The plant with which the foundry was connected needed a constant supply of abrasion-resisting castings, therefore the only problem to be solved was how to melt the material so the resulting metal could be handled and poured satisfactorily over the lip of the ladle. Early experiments indicated that the usually recommended high fuel ratio and use of high ferrosilicon are not required. Heats of 30 tons are poured daily seven days a week without any more trouble than is experienced in running off the usual gray-iron heats of the same tonnage.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Diesel Engines

DIESEL ENGINES. By David Louis Jones. Norman W. Henley Publishing Co., New York, 1926. Cloth, 6 × 9 in., 565 pp., 341 illustrations. $5.

THIS book was written and compiled with the object of presenting to the practical operating engineer the elementary principles of the Diesel engine, and instructions for its care and operation. The author believes that there is a dearth of experienced Diesel-engine operators for ship and power-station work, and that the need is particularly keen in the U. S. Navy, with whose requirements he is naturally well acquainted through his duties as an instructor in the U. S. Navy Submarine School. He is of the opinion that most books on Diesel engines are not suitable for the practical man because they delve too deeply into thermodynamics and matters of theory and design, whereas what he really wants is information that will be useful to him in his every-day work of operating and repairing.

After some introductory chapters on elementary thermodynamics, elementary principles, and comparative efficiencies, the constructional features of engines, such as fuel pumps, spray valves, and exhaust valves, are described, and with the descriptions of typical designs, practical information of use to the operator is given. This is followed by chapters on lubricating and cooling-water systems, indicator cards and engine testing, properties of lubricating and fuel oils, and general operating instructions. Representative types of engines are set forth and also special applications such as Diesel-electric drive for ships and Diesel engines for railroad service. Lloyd's rules for marine oil engines are quoted in detail, and a chapter entitled 200 Diesel Engine Pointers is reprinted from *Power*.

This book is based upon the experience of an expert mechanic who has acquired an intimate knowledge of the working characteristics of Diesel engines, particularly those of the marine type, and it abounds with practical notes that should not only aid the average operating man, but also be instructive to engine designers interested in learning how their concepts actually work. Engineering students, as well, should find in these comments much enlightenment which will aid them in acquiring a better understanding of the relative merits of different designs than can be obtained from a study of drawings alone.

The purpose of this volume would have been better accomplished if the sound practical advice based upon the author's own experience had been concentrated into a few short chapters instead of being scattered throughout the book and intermingled with much other descriptive matter of little or no value. For instance, in the chapter entitled Details of Construction the causes of piston seizures and cracked pistons are clearly and usefully presented, but this is followed immediately by a trite and valueless description of connecting-rod designs.

The danger of this to the unversed operating man is that he is unable to distinguish between the important practical advice and the unimportant or even incorrect statements. After assimilating some excellent counsel on the cutting of oil grooves in bearings, will he not become the victim of the statement that "non-cooled pistons are only suitable for small engines of less than twelve-inch bore," and thereupon look with suspicion on the engines of several reputable makes that successfully use uncooled pistons more than twenty inches in diameter?

The question may properly be raised as to whether the book might not have been improved by entirely omitting all general descriptions of engine parts. Not only are such descriptions better given in other works on Diesel engines, but the average operator soon learns the construction of his own engine better than he can gain it from any book. Certainly if he is running a large engine with inlet valves having a cast-iron head fastened to a steel stem, his time is wasted by reading the statement that inlet valves have head and stem made of one piece of steel. At the best it is difficult in any book to incorporate really useful descriptions of up-to-date engines, and in a work of this kind such descriptions are hardly required. The operating man, if he wishes to understand the construction of other modern engines than his own, can more easily do so by regularly reading one of the trade papers.

Excluding the practical pointers on care and operation, much of this book is a compilation of matter originally published elsewhere. The Diesel Engine, by Herbert Haas, published by the Bureau of Mines in 1918, has been drawn upon for several engine descriptions and for a statement of the desirable properties of fuel oils. Two of the makes of engines described are no longer in use, and much has since been learned about satisfactorily burning fuels that were considered undesirable when that book was published. The omission of practical advice on burning heavy fuel oils, such as Bunker C, is to be regretted. Manufacturers' catalog material has been incorporated with little editing. One firm is said to manufacture Diesel engines in a range of sizes from 80 to 8000 hp., whereas in fact the largest engine they have built to date is one of 2700 b.hp.

Some operating matters have been most satisfactorily treated and are evidently based upon the author's direct experience. Other matters, particularly those pertaining to stationary engines, have received inadequate attention. Only eight lines are given to the discussion of governors for stationary engines, and far too little attention is given to the important subjects of jacket-water systems and methods of avoiding scale formation.

The chapters on Diesel-electric drive for ships and on Diesel engines for railroad service consist almost entirely of catalog material which, while interesting, is of little direct value to the operating engineer.

Notwithstanding some of its unnecessary contents, this book will serve a useful purpose.

EDGAR J. KATES.[1]

Books Received in the Library

AIRCRAFT YEAR BOOK, 1926. Aeronautical Chamber of Commerce of America, New York, 1926. Cloth, 6 × 9 in., 331 pp., illus., diagrams, $5.25.

The 1926 Year Book presents the customary review of the developments of the year in commercial aviation in America and abroad. It gives a concise account of the principal events in this country—commercial, governmental, and technical. Chapters are devoted to special uses of aircraft in agriculture, exploration, etc. Legislative needs are discussed. A chronology and revision of the year are given, as well as a summary of technical development. Appendices contain data on commercial and technical associations, government services and appropriations, etc.

[1] Chief Engineer, Oil Engine Department, De La Vergne Machine Co., New York. Mem. A.S.M.E.

American Machinists' Handbook. By Fred H. Colvin and Frank A. Stanley. Fourth edition. McGraw-Hill Book Co., New York, 1926. Fabrikoid, 4 × 7 in., 972 pp., illus., tables, $4.

The new edition of this popular handbook is but little larger than its predecessor, which it closely resembles in appearance. The authors state, however, that it has been thoroughly revised and that much of the earlier material has been replaced by new standards and shop practices, so that the book is again representative of the best current practice.

Employee Representation. By Ernest Richmond Burton. Williams & Wilkins, Baltimore, Md., 1926. (Human Relations series.) Cloth, 6 × 8 in., 283 pp., tables, $3.

The author presents a careful investigation of employee representation which has occupied his time during the past seven years. His purpose has been to ascertain the history of the movement, the reasons that have prompted employers to adopt the plan, the extent to which it has achieved the objects sought, and the difficulties that have beset the movement. The book also endeavors to define the place and function of employee representation in the policy of personnel relations, and to indicate the desirable direction of its development.

English Applied in Technical Writing. By Clyde W. Park. F. S. Crofts & Co., New York, 1926. Cloth, 6 × 8 in., 313 pp., $2.25.

This book, by a professor of English in the College of Engineering and Commerce, University of Cincinnati, is intended for use as a textbook in technical schools. The aim of the author is to assist the student to acquire a clear personal style and the ability to express his ideas correctly in practical writing. Throughout the book, instruction in English is linked with the written work done by the students in their technical courses. The book is not only a good text, but will also be useful as a reference book for counsel.

Enlarged Heat Drop Tables. H. P. Gauge Pressures, L. P. Absolute Pressures. By Herbert Moss, from the formulas and enlarged steam tables of H. L. Callendar. Edward Arnold & Co., London, 1925. Cloth, 6 × 9 in., 88 pp., $3.75.

In 1917 Mr. Moss published a set of tables, based on Professor Callendar's formulas and tables, showing the adiabatic heat drop of steam with initial pressures up to 400 lb. per sq. in. and vacua from 27.0 to 29.1 in. The present book supplements the original set. It gives new tables of the adiabatic heat drop of 1 lb. of steam, in British thermal units, for initially dry saturated or supersaturated steam of pressures from 400 to 2000 lb. per sq. in. gage and vacua from 27.0 to 29.5 in. of mercury. It also extends the original tables to vacua from 29.2 to 29.5 in.

Enlarged Mollier or H-Φ Diagram for Saturated and Superheated Steam. Plotted by H. L. Callendar from his enlarged steam tables. Edward Arnold & Co., London, 1926. Paper, 30 × 40 in., $1.35.

An excellent diagram, clearly printed on heavy paper and sufficiently large to be read easily.

Mechanics for Engineering Students. By G. W. Bird. Isaac Pitman & Sons., New York and London, 1926. (Technical School series.) Cloth, 6 × 9 in., 142 pp., diagrams, $1.50.

A concise textbook covering the subjects required as preparation for the British National Certificate examination. The course is designed for one year and is marked by the large number of worked-out examples.

Methods of Teaching Industrial Subjects. By Arthur F. Payne. McGraw-Hill Book Co., New York, 1926. Cloth, 6 × 9 in., 293 pp., $3.

The teacher of industrial subjects, selected because of his mastership of some trade, usually finds himself to be a novice in the profession of teaching and handicapped by his ignorance of the philosophy, principles, and technique of teaching.

To remedy this situation he must master the techniques of his new profession, and the present book is a contribution toward that end. It brings together the fundamentals of the techniques of teaching, presents them as simply as possible, and indicates their use in the teaching of industrial subjects. Good bibliographies are given.

Photographic Photometry. By G. M. B. Dobson, I. O. Griffith, and D. N. Harrison. Clarendon Press, Oxford, 1926. Cloth, 5 × 8 in., 121 pp., plates, diagrams, tables, 7s. 6d.

In view of the increasing applications of photographic methods for measuring the intensity of light, this book by authors, who have spent much time and research during recent years on the best technique for photographic photometry, will be welcome. In it is reviewed the whole subject, theory and practice. The principal methods employed, the sources of errors, how these errors can be minimized, and generally how to find the best method of working, are the topics here discussed. The book should prove most useful to any one starting work in this subject.

Principles Underlying the Design of Electrical Machinery. By W. I. Slichter. John Wiley & Sons, New York, 1926. Cloth, 6 × 9 in., 312 pp., illus., diagrams, tables, $3.75.

Dr. Slichter's book is developed from a course of lectures given at Columbia University and from his experience as a designing engineer. It is to some extent an amplification of his articles on the subject which were written for Pender's Handbook of Electrical Engineering.

The purpose throughout is to give a practical method of design, with explanations of the physical meaning of the arbitrary constants used by the professional designer. To assist in this the author derives the formulas from fundamental principles, explains each of them, and gives the reasons for the various standards of practice. He gives a systematic method of procedure for the design of each type of machine treated, with a complete sample calculation in each case.

The book is intended as a text for a course in design. It will also be an aid to young engineers through its explanation of the reasons for certain conventional practices.

Railroad Freight Service. By Grover G. Huebner and Emory R. Johnson. D. Appleton & Co., New York, 1926. Cloth, 6 × 9 in., 589 pp., diagrams, forms, maps, $5.

Written to assist railroad officials and those in charge of the traffic and transportation activities of industries. The book describes in detail the railroad-freight services, freight-traffic rules and practices, and the organization of the departments that perform the services. The authors have succeeded in compressing a comprehensive account of the railroad-freight service, in all its phases, into a single volume.

Story of Steel. By J. Bernard Walker. Harper & Bros., New York, 1926. Cloth, 6 × 8 in., 208 pp., illus., $4.

A non-technical description of the manufacture of steel as carried on in this country, based on an extended inspection of the properties and methods of the United States Steel Corporation. Starting at the Minnesota mines, the author traces the processes through the blast-furnace and the steel furnace to the finished sheet, pipe, and section. Chapters are also devoted to the social and economic policies of the corporation.

Treatise on Hydraulics. By Hector J. Hughes and Arthur T. Safford. Revised and abridged. Macmillan Co., New York, 1926. (Engineering Sciences series.) Cloth, 6 × 9 in., 365 pp., illus., diagrams, tables, $4.

The aim of the authors has been to provide a textbook of practical hydraulics, accompanied by sufficient experimental data and hydraulic tables to make it useful to the engineer in solving his everyday hydraulic problems. The text is confined to the simpler phases of hydraulics, and the design and construction of machinery are not discussed. On the other hand, the authors have attempted to include practically all of the reliable experimental work that has been carried out within their field, and to present an unusually large amount of experimental data.

L'Union d'Electricité. By H. Brès. Revue Industrielle, Paris, 1926. Paper, 5 × 8 in., 63 pp., illus., 10 fr.

A pamphlet describing recent additions to the Gennevilliers power station of the Union d'Électricité and installations of new machinery in its Vitry plant. The additions comprise 50,000-kw. turbo-alternators, pulverized-coal boiler plants, and numerous other improvements on a large scale.

THE ENGINEERING INDEX

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Mechanical Engineering Section

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ABRASIVE WHEELS

Standard Types. Standard Types of Grinding Wheels. Am. Mach., vol. 65, no. 11, Sept. 9, 1926, p. 465. Reference-book sheet. Simplified-practice standards.

ACCELEROMETERS

Types. Accelerometers, F. Paulsen. Elec. Jl., vol. 23, no. 9, Sept. 1926, pp. 475–478, 12 figs. Simple forms of accelerometers; mechanical and hydraulic types; electrical accelerometers. Bibliography.

ACCIDENT PREVENTION

Industrial. Industrial Accidents and Hygiene. Monthly Labor Rev., vol. 23, no. 2, Aug. 1926, pp. 41–46. Problem of national accident statistics; what is being done in collection of accident statistics; and to develop national accident-prevention statistics; other phases of accident-prevention problem; resolutions passed by Conference.

AERONAUTICS

Düsseldorf Exhibition, Germany. Aeronautical Exhibits at the Düsseldorf Exhibition, Germany (Die deutsche Luftfahrt auf der Gesolei). Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 11–12, June 28, 1926, pp. 223–262, 46 figs. Contains contributions by different writers on aeronautical exhibits at the Gesolei, which is name given exhibition in Düsseldorf; effort has been made to give complete demonstration of production of airplane or airship, running from scientific investigations, through designing room and detail manufacture, to complete airplanes and large airship models; then follow collections of instruments, samples of aerial photography, glider exhibits, and exhibits illustrating history of flight; arrangement of exhibition was entrusted to German Scientific Assn. for Aeronautics (WGL).

AIR COMPRESSORS

Piston, Heat Transmission. Calculation of Intermediate Coolers of Piston Compressors (Berechnung der Zwischenkühler von Kolbenverdichtern), H. Jeschke. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 33, Aug. 14, 1926, pp. 1100–1102, 6 figs. Develops equation for calculation of heat-transmission coefficient with aid of well-known heat-transmission formula.

Turbo. Turbo Compressors and Turbo Blowers (Turbo-Compresseurs et Turbo-Soufflantes), E. Moerlen. Société Alsacienne de Constructions Mecaniques—Bul., vol, 4, no. 15, July 1926, pp. 59–69, 13 figs. Design and construction of Société Alsacienne machines, their advantages, fields of application, control; constant and variable speed regulation.

AIR CONDITIONING

Air Tester. The Air Tester, R. C. Frederick. Analyst, vol. 51, no. 605, Aug. 1926, pp. 397–400. Apparatus is invention of A. W. C. Menzies, intended for popular use; it depends for its manifestations upon evaporative power of air in which it is situated, that is, collective influence of temperature, humidity and air movement.

Principles and Apparatus. Air-Conditioning and Air-Conditioning Apparatus, J. W. Cooling. Domestic Eng. (Lond.), vol. 46, nos. 7 and 8, July and Aug. 1926, pp. 140–145 and 157–163, 11 figs. Control of temperature, humidity, cleanliness, and air distribution; air-conditioning apparatus; automatic controls.

Problems. Air Conditioning, S. C. Bloom. Refrig. Eng., vol. 13, no. 1, July 1926, pp. 10–13 and (discussion) 13–15. Term includes heating, cooling, humidifying, dehumidifying, purifying, and distributing air for regulation of atmospheric conditions within enclosed spaces; deals with offices and cooling problem.

AIRPLANE ENGINES

Air-Cooled. Air-Cooled Engines in Naval Aircraft, E. E. Wilson. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 221–227, 2 figs. Points out basic policies which have resulted in fostering of air-cooled engine development by Navy, and indicates where development has led.

Some Problems in the Design of an Air-Cooled Radial Engine, R. W. A. Brewer. Aviation, vol. 21, no. 10, Sept. 6, 1926, pp. 410–411. Considers problems which confront designer, such as brake horsepower, speed of revolution, cooling and cowling, weight, number of cylinders, disposition of accessories, lubrication and fuel arrangement, kind of fuel to be used, mounting, type and arrangement.

Armstrong-Siddeley Genet. The Armstrong Siddeley Genet. Aeroplane, vol. 31, no. 8, Aug. 25, 1926, pp. 252 and 254, 8 figs. Low-powered engine designed to come within weight limit of 170 lb. laid down by Royal Aero Club for forthcoming Two-Seater Light Aeroplane Trials, and at same time to be of adequate power and size to give reasonable performance and high degree of reliability in practical touring two-seater; it is 5-cylinder, radial air-cooled type.

Compression-Ignition. The High-Duty Compression-Ignition Engine, D. R. Pye. Engineering, vol. 122, no. 3163, Aug. 27, 1926, pp. 277–279, 1 fig. Describes what has been done toward development of engine burning heavy oil for use in air; this type of engine offers great possibilities of development, both as regards fuel economy and saving of weight in material. Paper read before Sect. G, Brit. Assn. See also Gas & Oil Power, vol. 21, no. 252, Sept. 2, 1926, pp. 259–261.

Developments. Progress in Aircraft-Engine Design, A. Nutt. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 239–247, 14 figs. Reviews marked advance made in last ten years in constructional details, in airplane-engine and airplane performance; describes each type of engine produced successively by Curtiss Airplane & Motor Co., Buffalo, and tells of changes made to improve performance.

Superchargers. A Roots-Type Aircraft-Engine Supercharger, A. W. Gardiner. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 253–264, 17 figs. Design, principles of operation and characteristics of Roots-type compressor and its slip speed due to air leakage past rotors, its pulsating discharge, type efficiency, and variation in torque; describes Roots-type supercharger as designed for use with Liberty-12 engine; set-up for laboratory tests; gives reasons for conclusion that Roots-type compressor seems to be well adapted for use as aircraft-engine supercharger.

Wright-Morehouse. The Wright-Morehouse 25–30 hp. Airplane Engine, G. Vaughan. Aviation, vol. 21, no. 8, Aug. 23, 1926, pp. 329–331, 2 figs. Twin-cylinder horizontally opposed air-cooled engine for light airplanes.

Wright Whirlwind. The Development of the Wright Whirlwind Type J-5 Aircraft-Engine, E. T. Jones. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 303–308 and 320, 9 figs. Author discusses bearing of this engine on present status of air-cooled aircraft engine; it embodies two distinct forms of cylinder construction; application of these cylinders to engine under discussion is outlined and subsequent development traced.

Wright "J" Type Engine is Result of Extensive Service Tests, A. F. Denham. Automotive Industries, vol. 55, no. 10, Sept. 2, 1926, pp. 380–381, 1 fig. Review of developments since Whirlwind rotary was designed five years ago.

AIRPLANE PROPELLERS

Airplane Structure and. Interaction Between Air Propellers and Airplane Structures, W. F. Durand. Nat. Advisory Committee Aeronautics—Report, no. 235, 1926, 23 pp., 36 figs. Investigation conducted at Leland Stanford Junior University, to determine character and amount of interaction between air propellers as usually mounted on airplanes and adjacent parts of airplane structure.

Characteristics. Navy Propeller Section Characteristics as Used in Propeller Design, F. E. Weick. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 244, Aug. 1926, 7 pp., 10 figs. Artificial aerodynamic characteristics of set of propeller sections to be used in designing propellers by means of blade-element theory; characteristics computed from model propeller tests for single section are extended to cover sections of all thicknesses by means of model wing tests on series of Navy propeller sections at high Reynolds Number in variable-density tunnel of National Advisory Committee for Aeronautics.

Vibration. Airscrew Vibration and Gear Stripping, J. Morris. Roy. Aeronautical Soc.—Jl., vol. 30, no. 188, Aug. 1926, pp. 495–502, 2 figs. Author contradicts statement made by J. D. Siddeley in paper published in same journal in March 1925, in which he stated that inclusion of reduction gears has been responsible for limiting seriously degree of reliability of power unit; present author concludes that for proper solution of main problem under consideration flexibility of blades should be taken into account.

AIRPLANES

Airfoils. Aerodynamic Characteristics of Airfoils, Nat. Advisory Committee for Aeronautics—Report no. 244, 1926, pp. 191–230, 124 figs. Collection of data on airfoils made from published reports of number of leading aerodynamic laboratories of United States and Europe; information which was originally expressed according to different customs of several laboratories is here presented in uniform series of charts and tables suitable for use of designing engineers and for purposes of general references.

The Characteristics of the N.A.C.A. M-12 Airfoil Section, G. J. Higgins. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 243, Aug. 1926, 6 pp., 1 fig. Results of tests at 1 and at 20 atmospheres under improved conditions; considerable scale effect was found.

Metal. Metal-Airplane Construction in France (Der Metallflugzeugbau in Frankreich), R. Eisenlohr. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 33, Aug. 14, 1926, pp. 1109–1110, 5 figs. Author points out that whereas in Germany metal construction has developed rapidly within last 10 years with marked improvements in a number of works, French progress in this direction has been slow; gives examples of French metal and semi-metal types, latter making use of wooden parts and fabric covering.

Note.—The abbreviations used in indexing are as follows

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

Reliability Tour. Planes on Ford Tour Reflect New Trends in Design, L. S. Gillette. Automotive Industries, vol. 55, no. 10, Sept. 2, 1926, pp. 372–375, 11 figs. Landing-wheel brakes, self-starters and metal propellers coming into general use.

Rotating Wings. An Airplane with Rotating Wing (Avion à voilure tournante), J. L. Breton. Académie des Sciences—Comptes Rendus, vol. 182, no. 18, May 3, 1926, pp. 1079–1082. Details of Moineau vertical type, consisting of one or more paddle wheels, whose oblique action gives lifting power similar to that of helicopter.

The Rotating Wing in Aircraft, H. E. Wimperis. Engineering, vol. 122, no. 3162, Aug. 20, 1926, pp. 246–248, 3 figs. Author points out that there are two requirements which have been overlooked by most inventors, and which are difficult to meet; one is that aircraft must be controllable in flight, and the other that safe descent must be ensured when power unit is out of action; rotating-wing type of aircraft evidently has a future, but to what extent and in what fields it will prove to possess advantage over fixed-wing type remains for future discovery. Paper read before Sect. G, of British Assn.

Sikorsky. Sikorsky Trans-Atlantic Airplane a Redesigned "Freighter," A. F. Denham. Automotive Industries, vol. 55, no. 12, Sept. 16, 1926, pp. 462–463, 2 figs. Giant ship originally designed for high-speed transport but plans were later modified to adapt it for Captain Fonck's non-stop New York to Paris flight.

Spars. Spindles and Hollow Spars, J. D. Blyth. Flight (Aircraft Engr.), vol. 18, no. 34, Aug. 26, 1926, pp. 532e–532f. Tables prepared with object of making it possible to arrive with certainty at maximum amount of spindling or hollowing out permissible in case of any particular spar section.

Three-Engined. Three-Engine Planes for Air Transport, C. G. Peterson. Aviation, vol. 21, no. 9, Aug. 30, 1926, pp. 354–357, 7 figs. Points out that reliability and punctuality are insured by three-engine principle in commercial air transportation; comparative fuel costs.

AIRSHIPS

Fuel for. New Fuel for Dirigibles. Automotive Industries, vol. 55, no. 8, Aug. 19, 1926, p. 283. Account of experiments being made by German engineers with new gas which they plan to substitute for gasoline as fuel in super-Zeppelin they plan to construct; it is described as carbureted hydrogen gas, held superior to other liquid fuels because of increased economy and efficiency and virtual elimination of danger of explosion; its weight is same as atmosphere, and therefore no loss of weight or balance of airship results as gas is consumed.

Mooring. The Development of Airship Mooring, G. H. Scott. Roy. Aeronautical Soc.—Jl., vol. 30, no. 188, Aug. 1926, pp. 459–474 and (discussion) 474–481. Discusses question of riding to and landing to mooring mast; describes new mooring mast under construction at Ismailia, Egypt, consisting of steel girder structure arranged in form of octagon; contains appendices on history of mast mooring; and method of calculating for airship moored to mast, degree of instability due to temperature gradient and external weight necessary to counteract it.

Shenandoah Disaster. Technical Aspects of the Loss of the U.S.S. Shenandoah. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 3, Aug. 1926, pp. 487–694, 29 figs. Conclusions arrived at by National Advisory Committee for Aeronautics in design of Shenandoah; account of Lt. Commander C. E. Rosendahl, Senior Surviving Line Officer; testimonies of other survivors; angular and vertical acceleration; gas-pressure stresses; stresses in longitudinals; pressure after falling 3000 ft.; effect of increased stretch of netting wires; hypothetical problems on gas-cell pressure; Bureau of Standards report on tests of material from Shenandoah submitted by Court of Inquiry; general account of events; cause of breaking of ship; recommendations for future developments.

ALLOY STEEL

Chemically Resistant. Chemically Resistant Steels—with Special Reference to Very High and Very Low Temperatures, T. G. Elliot and G. B. Willey. Chem. & Industry, vol. 45, no. 31, July 30, 1926, pp. 526–534, 7 figs. Discusses properties of steels for very high and very low temperatures; newer types of nickel-chromium and other steel alloys mentioned offer great promise to chemical engineer for nitrogen fixation, synthetic ammonia, oil cracking, nitric acid, etc.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.
Bronzes. See BRONZES.
Copper. See COPPER ALLOYS.
Gun Metal. See GUN METAL.
Iron Alloys. See IRON ALLOYS.

ALUMINUM

Casting. See CASTING, Aluminum.

Castings. Aluminum Castings of High Strength, R. S. Archer and Z. Jeffries. Am. Inst. of Min. & Met. Engrs.—Trans., no. 1590-E, Sept. 1926, 26 pp., 5 figs. Describes compositions and processes which appear to authors to offer greatest promise for production on commercial scale of aluminum castings of superior mechanical properties, with special reference to heat-treated castings; tests for suitability of alloy; casting characteristics; toughness in castings; heat treatment of castings; commercial development of heat-treated castings; "Y" alloy castings; recent laboratory results.

Corrosion. Corrosion of Aluminum by Water (Untersuchungen über die Angreifbarkeit von Aluminium durch Wasser), L. W. Haase. Zeit. für Elektrochemie, vol. 32, no. 6, June 1926, pp. 286–289, 2 figs. Experiments on corrosion of aluminum were made by placing samples of surface, drinking and sewage water in corked aluminum flasks and following changes in hydrogen-ion concentration and conductivity and determining aluminum hydroxide formed; all samples of water attacked aluminum more or less, sometimes with formation of holes; corrosion was greatest at bottom of flasks and at liquid-air boundary which was explained both electrolytically and electrochemically. See brief translated abstract in Chem. & Industry, vol. 45, no. 34, Aug. 20, 1926, pp. 671–672.

Corrosion, Protection Against. The Protection of Aluminum and Its Alloys Against Corrosion by Anodic Oxidation, G. D. Bengough and H. Sutton. Engineering, vol. 122, no. 3163, Aug. 27, 1926, pp. 274–277, 6 figs. Authors find that film produced by anodic oxidation in bath containing chromate, bichromate or chromic acid is effective method of protecting against corrosion; details of treatment of various alloys of aluminum by this method, results of testing such treated specimens in sea water, and development of process on technical lines. Paper read before Sect. G of Brit. Assn. See also Metal Industry (Lond.), vol. 29, nos. 7 and 8, Aug. 13 and 20, 1926, pp. 153–154 and 175.

Soldering. Aluminum Soldering in the United States and in Germany (Ueber das Löten von Aluminium in den Vereinigten Staaten von Amerika und in Deutschland), L. Rostosky and E. Lüder. Zeit. für Metallkunde, vol. 18, no. 7, July 1926, pp. 224–227. Compares development in America and Germany based on report of Bureau of Standards on aluminum soldering in America; discusses German effort to produce aluminum-rich solder (containing over 50 per cent aluminum).

ALUMINUM ALLOYS

Aluminum-Cadmium-Zinc. Aluminum-Cadmium-Zinc Alloys, N. F. Budgen. Brass World, vol. 22, no. 8, Aug. 1926, pp. 247–250, 9 figs. Preliminary survey of present knowledge concerning their mechanical properties; tests show surprising effects of small changes in relative proportions of metals.

Aluminum-Silicon. The Constitution and Structure of the Commercial Aluminium-Silicon Alloys, A. G. C. Gwyer. Inst. Metals—Advance Paper, no. 404, for mtg. Sept. 1–4, 1926, 43 pp., 54 figs. Constitution, structure, and mechanical properties of modified aluminum-silicon alloys; theory based upon colloidal lines is put forward to explain nature of modified structures; application of this theory to other alloy systems; alloys possess good founding qualities; are appreciably lighter than pure aluminum, and in both chill- and sand-cast states possess high resistance to shock, excellent ductility, and high degree of incorrodibility; contains appendix on properties of modified aluminum-silicon alloys.

Some Mechanical Properties of Silicon-Aluminium Alloys, J. D. Grogan. Inst. Metals—Advance Paper, no. 405, for mtg. Sept. 1–4, 1926, 13 pp., 8 figs., also abstract in Engineering, vol. 122, no. 3165, Sept. 10, 1926, pp. 341–342, 4 figs. Describes sodium and "salts" methods of modifying these alloys; latter method is preferred; mechanical properties of 1-in. diameter chill- and sand-cast bars; ternary alloys containing also magnesium or zinc are not superior to binary alloys.

Aluminum-Zinc. The System Aluminum-Zinc (Zur Erforschung des Systems Aluminium-Zink), O. Tiedemann. Zeit. für Metallkunde, vol. 18, no. 7, July 1926, pp. 221–223, 3 figs. Tensile tests on series of alloys of aluminum with up to 20 per cent zinc with different heat-treating methods.

Silumin. Silumin and Its Structure, B. Otani. Inst. Metals—Advance Paper, no. 401, for mtg. Sept. 1–4, 1926, 25 pp., 27 figs. Equilibrium diagram of aluminum-silicon alloys has been redetermined; solubility of silicon in solid aluminum was studied by two methods: experiments in production of silumin regarding amount of modifying agent necessary and temperature most suitable for reagent selected; it was shown that caustic alkali may be used as modifying reagent. See also abstract in Engineering, vol. 122, no. 3165, Sept. 10, 1926, pp. 336–338, 25 figs.

AMMONIA

Heat Diagram. Ammonia Heat Diagram—How to Use It, T. M. Gunn. Refrigeration, vol. 40, no. 2, Aug. 1926, pp. 44–46, 1 fig. Examples of use of chart prepared by Bureau of Standards.

AMMONIA COMPRESSORS

Atmospheric Pressure, Effects of. Atmospheric Pressure Affects Ice Machines, W. H. Motz. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 1019–1020. Analysis of difference in capacity and power consumption between identical machines with different barometric pressures.

Horizontal High-Speed. The First Ten Years of Horizontal High Speed Ammonia Compressors, L. H. Roller. Refrig. Eng., vol. 13, no. 1, July 1926, pp. 1–7 and (discussion) 7–9, 17 figs. Study of engineering records of De La Vergne Machine Co., covering first ten years of high-speed compressors.

Improvement. Recent Improvements in Refrigerating Compressors. Power Engr., vol. 21, no. 246, Sept. 1926, pp. 336–337, 1 fig. Effect of increased speed on methods of construction.

Leakage Reduction. How to Reduce Ammonia Compressor Leakage, F. H. Randolph. Power, vol. 64, no. 11, Sept. 14, 1926, pp. 404–405. Suggests proper precautions in plants having difficulty in getting proper results from compressor stuffing box.

APPRENTICES, TRAINING OF

Foundry. Creates Supply of Skilled Labor, R. A. Fiske. Iron Age, vol. 118, no. 12, Sept. 16, 1926, pp. 766–768 and 823, 4 figs. Chicago foundry conducts apprenticeship course in molding, patternmaking and toolmaking; both class-room instruction and shop training provided.

Training Boys for the Foundry, E. N. Simons. Foundry Trade Jl., vol. 34, no. 523, Aug. 26, 1926, pp. 175–176. In majority of foundries, system of "learnership" is in force; these usually comprise precise verbal agreement between employer and lad that later shall have opportunity to pick up trade at former's plant, though employer is not bound to teach lad; examination of methods of training adopted.

AUTOMOBILE ENGINES

Cooling. Thermo-Vapor Engine-Cooling System, C. H. Kenneweg. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 295–297, 1 fig. Describes cooling system as combination of thermosiphon system in which boiling water is circulated rapidly through engine block, and condenser system for dissipating excess heat.

Crankcase-Oil Dilution. Eliminating Dilution by the Application of Heat, J. C. Coulombe. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 282–287, 4 figs. Attempt has been made to design heating unit that will keep heat unit submerged continually and will pass oil through quickly; describes such device placing special stress on necessity for overflow tube that goes entirely through cylindrical filter.

Sources of Contamination of Crankcase Oil, R. L. Skinner. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 275–279, 4 figs. Results of tests made with and without use of rectifier; recommends that all new internal-combustion engines be provided with suitable equipment for positive prevention of dilution, for it will then be possible to maintain viscosity pour test and flash point of crankcase oil over greatly increased period.

Fuels. See AUTOMOTIVE FUELS.

Oil Rectifiers. The Oil-Rectifier, W. G. Wall. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 279–282, 3 figs. Describes rectifier designed to take out all water and to keep diluent between 4 and 5 per cent and vicosity above 250 sec. at 100 deg. fahr., oil being forced through by pressure of oil pump at rate of about 3 gal. per hr.

Pistons. See PISTONS.

Variable-Compression-Ratio. The Variable-Compression Ratio Motor, A. L. Nugey. Oil Trade, vol. 17, no. 9, Sept. 1926, pp. 21–22. In author's opinion, application of new principle, namely, motor with variable-compression ratio, will be fully realized, especially by automotive industry.

AUTOMOBILE MANUFACTURING PLANTS

Germany. The Benz Works at Gaggenau (Die Benzwerke Gaggenau). Automobil-Rundschau, vol. 28, nos. 3, 5, 7 and 8, Mar., May, July 1 and 15, 1926, pp. 53–59, 113–118, 163–166 and 189–193, 48 figs. Mar.: Design of chassis; types of buses and trucks constructed in works. May: Low-slung buses and special cars. July: Workshops and equipment. For reference to first installment of article, see Eng. Index 1925, p. 50.

Oakland Motor Car Co. Oakland Departs from Orthodox Practice in Press Room Layout, W. L. Carver. Automotive Industries, vol. 55, no. 8, Aug. 19, 1926, pp. 290–291, 4 figs. Machines arranged irregularly to facilitate straight-line production; ingenious design of continuous-chain conveyor allows free use of traveling crane; man power is reduced.

AUTOMOBILES

Parts, Manufacture of. A Modern Plant for the Manufacture of Automotive Parts. West. Machy. World, vol. 17, no. 8, Aug. 1926, pp. 341–343, 8 figs. Methods and equipment of new plant of Mann Manufacturing Co., Berkeley, Cal.

Shock Absorbers. Shock Absorber Will Be Used as Steering Damper on New Marmons, P. M. Heldt. Automotive Industries, vol. 55, no. 8, Aug. 19, 1926, pp. 300–301, 2 figs. Novel application of Hartford device is said to eliminate "shimmy" trouble at all car speeds.

Spring Suspension. Relation of Spring-Suspension to Riding-Qualities, F. C. Mock. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 288–294, 9 figs. Analysis of spring action such as occurs on automobile driven on highway having bumps and depressions; requirements of spring-recoil checking devices, and experiments made with car on which different combinations of springs of various lengths and flexibilities were used and distribution of weight on frame was varied; points out limitations of shock absorber or recoil-check design; results of experiments with car on road.

AUTOMOTIVE FUELS

Alcohol. Experiences with Alcohol Motor Fuels, J. D. Ross and W. R. Ormandy. Chem. & Industry, vol. 45, no. 33, Aug. 13, 1926, pp. 273T–280T, 8 figs. Modern researches into nature and behavior of various types of fuel in automobile cylinder; test to determine for any given speed lowest possible fuel consumption irrespective of power, and greatest mean pressure developed with reasonable economy; experiments demonstrated that alcohol in small percentage through its anti-detonating power enables better use to be made of low-grade gasoline.

Anti-Knock. Anti-Knock Fuel (Sur l'effet retardateur d'inflammation produit par les corps dits antidétonants), M. Dumanois. Académie des Sciences—Comptes Rendus, vol. 182, no. 25, June 21, 1926, pp. 1526–1528. Points out that only fundamentally sound means of avoiding knock is engine design which permits mechanical cooling to control ignition temperature and pressure; pending adoption of such a design, next best solution is use of detonation retarder such as tetraethyl lead; experiment using gas mixture containing 1/1000 part of lead tetraethyl has shown that premature explosion is perceptibly diminished by this substance.

New Anti-Detonants (Antidetonanti nuovi), G. Ferreri. Giornale di Chimica Industriale ed Applicata,

vol. 8, no. 6, June 1926, pp. 314–315. Proposes use of metallic naphthenates prepared from naphthenic acids.

The New Fuel "Gasin" (Ueber den neuen Kraftstoff "Gasin"), G. Grote. Chemiker-Zeitung, vol. 50, no. 79, Aug. 14, 1926, pp. 603–604. Shows from experiments that knocking is due to want of electrical conductivity of gas mixtures and can be eliminated by using fuel of good conductivity such as "Gasin," which is 30 per cent gasoline plus 70 per cent benzol; comparative tests gave satisfactory results; with use of gasin, engine did not knock, started well cold or hot, and ran smoothly and without knocking on full load at low speed, although no preheating of mixture was done. See translated abstract in Chem. Age, vol. 15, no. 373, Aug. 21, 1926, p. 181.

Benzol. See BENZOL.

Spontaneous Ignition. Spontaneous Ignition of Carburetted Fuel Mixtures (L'Auto-inflammation des mélanges carburés), A. Pignot. Jl. des Usines à Gaz., vol. 50, no. 15, Aug. 5, 1926, pp. 293–298, 12 figs. Discusses difficulty encountered in increasing coefficient of compression in explosion engines due to premature ignition and studies flammability of carburetted fuel mixtures from this point of view.

AVIATION

Airports. Aerial Ports, Layout and Equipment (Flughäfen, ihre Anlage, Einrichtung und allgemeine Bedeutung), Luftfahrt, vol. 30, no. 12, June 20, 1926, pp. 182–185, 7 figs. Discusses location and requirements to be met for German and other airports; landing places, ports for airplanes and for flying boats, starting and landing equipment, lighting, etc.

Lighting Equipment. Lighting Equipment for Airways, Airports and Airplanes. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 309–319, 22 figs. In Part I, by H. C. Ritchie, navigational aids needed to enable pilot to keep on his course are discussed. Part II, C. T. Ludington outlines certain other phases of aeronautic lighting and particularizes on products of company represented by author.

Russia. Aviation in Russia (Russland als Absatzland für deutsche Kraftfahrzeuge), G. Plum. Motorwagen, vol. 29, no. 17, June 20, 1926, pp. 378–381. Author predicts that aeronautical transportation will probably develop more easily in Russia than automobile transportation, due to poor condition of roads and to long distances; Junkers has branch factory in Russia where he is in better position to promote developments than in Germany.

B

BEARING METALS

Tests. Tests of Several Bearing Materials Lubricated by Gasoline, W. F. Joachim and H. W. Case. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 241, July 1926, 19 pp., 3 figs. Investigation conducted at Langley Aeronautical Laboratory, Langley Field, Va., as part of general research on fuel-injection engines for aircraft; special purpose of work was to find durable bearing material for gear pumps to be used for delivery of gasoline and Diesel-engine fuel oil at moderate pressures to high-pressure pumps of fuel-injection engines.

BEARINGS

Journal. Causes of Hot Journal Bearings (Studien über Achslager für Fahrzeuge), E. Schulze. Verkehrstechnik, vol. 43, no. 26, June 25, 1926, pp. 417–423, 24 figs.; also translated abstract in Elec. Ry. Jl., vol. 68, no. 8, Aug. 21, 1926, pp. 300–302, 7 figs. Investigation made to determine how periods between oilings of journal bearings could be lengthened; how deformation and displacement of bearings could be prevented and causes for hot bearings; weakness of axle brasses; introduction of journals of cast steel with brass lining.

BENDING

Tests. Material Bend Tests. Machy. (Lond.), vol. 28, no. 722, Aug. 12, 1926, p. 557. Admiralty bend test; machining of test pieces; grinding on test piece.

BENZOL

Automobile Fuel as. Tests of Benzole as a Motor Engine Fuel. Oil Eng. & Technology, vol. 7, no. 124, Aug. 1926, pp. 355–358, 5 figs. Examination of tendency to deposit resinous compounds on automobile engine parts.

BLAST FURNACES

Air Drying. Drying Air for Blast Furnaces with Silica-Gel, F. Krull. Iron & Coal Trades Rev., vol. 113, no. 3049, Aug. 6, 1926, pp. 191–192, 2 figs. Air drying is understood to mean reduction of water vapor or humidity content per weight unit of air in contradistinction to change in humidity of air by increase of temperature; previous drying processes; use of silica-gel as adsorbent. Translated from Zeit. des Vereines deutscher Ingenieure.

Flue-Dust Concentration. Magnetic Concentration of Flue Dust of the Birmingham District, O. Lee, B. W. Gandrud and F. D. DeVaney. U. S. Bur. of Mines—Reports of Investigations, no. 2761, July 1926, 16 pp. Characteristics and composition of flue dusts; magnetic properties and assays; large-scale tests; relative merits of wet and dry concentrators; conclusions.

BOILER FEEDWATER

Conditioning. Boiler Water Conditioning with Special Reference to High Operating Pressure and Corrosion, R. E. Hall. Combustion, vol. 15, no. 3, Sept. 1926, pp. 156–159, 1 fig. Scope of boiler-water conditioning; prevention of scale formation on evaporating surfaces; relation between chemical used in treatment and operating pressure; control of non-condensable gases in steam by conditioning of boiler water.

Equipment. The Selection and Operation of Modern Boiler Feed Equipment, C. L. Hubbard. Nat. Engr., vol. 30, no. 9, Sept. 1926, pp. 401–405, 12 figs. Operating principles, construction details, and applications of automatic water-level regulators; feedwater regulation problems in practice; type of regulators and their applications; construction details of different types of regulators.

BOILER FIRING

Honeycombing. Fuel Losses Resulting from Honeycombing and Excessive Clinkering, S. W. Parr. Combustion, vol. 15, no. 3, Sept. 1926, pp. 167–168. Points out that primary cause for honeycombing is presence of finely divided particles in coal as fired; clinkering of grates.

Industrial Power Plants. How Industrial Power-Plant Boilers Are Fired. Power, vol. 64, no. 12, Sept. 21, 1926, p. 445, 1 fig. Hand firing is still used in one-half of industrial plants; 35 per cent use automatic stokers.

BOILER PLANTS

Textile Mills. Modernized Boiler Plant and Electric Drive Nets 35 Per Cent on Investment, H. M. Wilson. Power, vol. 64, no. 12, Sept. 21, 1926, pp. 428–430, 5 figs. By replacing obsolete engine and power-transmission equipment with motors using purchased energy, and by substituting stoker firing with redesigned furnaces for hand firing, management of textile mill, with initial investment of $225,000, reduced annual operating cost from $195,000 to $115,000.

BOILER PLATES

Annealing. Annealing of Boiler Plate, S. P. Vologdin. Vestnik Metallopromyshlennosti, vol. 6, nos. 5–6, May-June 1926, pp. 5–9, 9 figs. Annealing of fine-grained plate may produce laminated or coarse-grained structure. (In Russian.)

BOILERMAKING

Seamless High-Pressure Boilers. Seamless Maximum-Pressure Boilers (Ueber nahtlose Höchstdruck-Kessel), Praktischer Maschinen-Konstrukteur, vol. 59, no. 25–26, June 26, 1926, pp. 267–269, 4 figs. Production of boiler shells from nickel-steel blocks by drilling, thus avoiding riveting and welding, followed by forging, annealing and finishing.

BOILERS

Barrel Plates. Boiler Barrel Plates. Ry. Engr., vol. 47, no. 560, Sept. 1926, pp. 306–307, 1 fig. Formula and chart for calculation.

Corrosion. Boiler Corrosion on the Canadian Pacific Railway, T. W. Lowe. Boiler Maker, vol. 26, no. 8, Aug. 1926, pp. 223–226. Report on Paper entitled "Boiler Fitting and Corrosion," presented at Master Boiler Makers' Assn.

The Problem of Steam Boiler Corrosion, F. N. Speller. Ry. Rev., vol. 79, no. 11, Sept. 11, 1926, pp. 375–383, 4 figs. Facts and theory and suggestions on feedwater treatment and care of boilers.

Electric. Electric Steam Generation, C. H. Tupholme. Elec. Rev., vol. 99, nos. 2543 and 2544, Aug. 20 and 27, 1926, pp. 292–293 and 331–333, 10 figs. Details of modern electric-boiler equipment.

Heads. Stresses and Behavior of Boiler Heads (Ueber die Beanspruchung und das Verhalten von Dampfkesselböden), E. Siebel. Stahl u. Eisen, vol. 46, no. 35, Sept. 2, 1926, pp. 1181–1191, 16 figs. Numerical and experimental investigations of boiler heads; measurements of deformations, expansions and stresses; development of calculating method for round heads; investigation of manhole heads, design and calculation; relation between stress distribution and flow phenomena on surface of head.

Joint Efficiency. Joint Efficiency Easily Checked with New Tables, A. G. Peterse. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 338–340. To determine safe working pressure of boiler, it is necessary to know efficiency of its riveted joints; presents tables compiled to eliminate tedious calculations necessary to determine weakest part of joint and efficiency.

Loss Analysis. Analyzing Boiler Losses, L. J. Levit. Power, vol. 64, no. 11, Sept. 14, 1926, p. 420, 2 figs. Author points out causes of boiler losses and shows their relative importance.

Locomotive. See LOCOMOTIVE BOILERS.

Tests. Operating Boiler Tests Show Important Relations. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, pp. 944–946, 6 figs. Variation of draft loss, superheat, efficiency and losses with rate of forcing and percentage of CO_2.

Waste-Heat. Growing Use of Waste Heat Boilers in Britain, C. H. S. Tupholme. Gas Age-Rec., vol. 58, no. 8, Aug. 21, 1926, pp. 245–248, 6 figs. Waste-heat boilers installed by Woodall-Duckham Co., provided with waste feedwater heaters or economizers.

Water-Gage Glass. A High-Pressure Water Gauge Glass. Engineer, vol. 142, no. 3685, Aug. 27, 1926, p. 232, 1 fig. With object of providing water-gage glass capable of safely withstanding high boiler pressures, R. Klinger, London, has made several modifications in its original form of prismatic glass, which shows water in black, while steam space is bright; this effect is produced by refraction from ribbed inside face of glass.

BRASS

Extruding. Problems in Extruding Brass, L. Kroll. Brass World, vol. 22, no. 8, Aug. 1926, pp. 253–254, 3 figs. Tested methods in obtaining good results; how to prevent cracking.

Porosity of Castings. Porosity and Physical Properties of Brass (Die Porosität und die physikalischen Eigenschaften des Rotgusses), W. Reitmeister. Zeit. für angewandte Chemie, vol. 39, no. 26, July 1, 1926, pp. 805–806. Considers porosity and other defects in brass castings; problems of proportions and purity of component metals, and of methods and conditions of casting, must be thoroughly studied if defects are to be overcome.

BRASS FOUNDRIES

Costs. Brass Foundry Costs. Brass World, vol. 22, no. 8, Aug. 1926, pp. 245–246. Careful analysis of fuel expense shows cost of gas for melting metal less than cost of labor for pouring.

Health Hazards. Health Hazards of Brass Foundries, J. A. Turner and L. R. Thompson. Metal Industry (N. Y.), vol. 24, no. 9, Sept. 1926, pp. 375–376. Results of field investigations; following conditions which have directly or indirectly detrimental influence upon health and efficiency of workers were observed to be present in foundries visited: exposure to dust; inadequate illumination and glare; inadequate ventilation; presence of fumes, gases, smoke, heat, cold, dampness.

BRONZES

Properties. Physical Properties of Engineering Materials. Power Engr., vol. 21, nos. 241, 242, 244 and 245, Apr., May, July and Aug., pp. 136–138, 183–185, 264–266, 294–295, 7 figs. Apr.: Gunmetal. May: Phosphor and Aluminum bronze. July: Silver bronze, manganese bronze; miscellaneous bronzes. Aug.: Manganese.

C

CASE HARDENING

Gas Furnaces for. Case Hardening and Fuel Costs. Metal Industry (Lond.), vol. 29, no. 8, Aug. 20, 1926, pp. 178–179, 2 figs. Application of gas heating to different heating processes connected with case-hardening and similar work; describes type of furnace for work with system of double regenerators; developed by Davis Furnace Co., Luton; it is known as Revergen and operates upon coal gas at ordinary main pressure.

Case-Hardening in Gas-Heated Furnaces, A. J. Smith. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, pp. 289–290, 1 fig. Application of reversible regeneration to case-hardening furnaces makes use of artificial gas a satisfactory and economical fuel.

Piston Rods. Carburizing Piston Rods and Long Tubes. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, pp. 491–492, 3 figs. Methods that have been developed for handling large pieces commercially; securing uniform work that must meet very severe specifications.

CAST IRON

Heat Treatment, Effect of. Improve Gray Iron Properties by Heat Treatment, O. W. Potter. Foundry, vol. 54, no. 17, Sept. 1, 1926, pp. 678–680, 3 figs. Results obtained from various tests for tensile, transverse and impact properties; results of tests for dimensional changes and hardness, showing in detail effect of heat treating on physical properties of cast iron.

Improvement. High-Grade Cast Iron (Hochwertiges Gusseisen). Zeit. für die gesamte Giessereipraxis, vol. 47, no. 29, July 18, 1926, pp. 325–326. Discusses recent efforts to produce cast iron of double usual tensile strength; use of higher melting temperatures and slower cooling; most suitable furnaces for minimum temperature of 1500 deg.; sulphur, carbon, and silicon content.

Improvement by Jolting. Improving Cast Iron by Jolting (Die Vergutung des Gusseisens durch Rüttelung), C. Irresberger. Giesserei, vol. 13, no. 24, June 12, 1926, pp. 425–427, 3 figs.; also English description in Foundry Trade Jl., vol. 34, no. 523, Aug. 26, 1926, p. 184, 7 figs. partly on p. 183. Describes new method of improving cast iron by jolting iron in liquid state; object is to free iron from gases and deoxidize it, to get thorough mixing, to render sulphur harmless and to dissolve graphite; special shaking hearth is employed in conjunction with 6-ton cupola.

Mechanical Properties. The Relation of the Mechanical Properties of Cast Iron to Each Other and to the Analysis (Die Beziehungen zwischen den mechanischen Eigenschaften untereinander und zur Analyse des Graugusses), T. Klingenstein. Giesserei, vol. 13, no. 9, Feb. 27, 1926, pp. 169–173, 11 figs.; also translation in Foundry Trade Jl., vol. 34, no. 522, Aug. 19, 1926, pp. 155–157, 8 figs. Investigations in respect to relations of mechanical properties of ordinary cast iron to its analysis; test results obtained in foundry at Esslingen during course of one year were evaluated by means of rule of probabilities, and results were checked by special experiments.

Testing. Shearing Tests to Determine Strength Properties of Cast Iron (Scherversuche zur Beurteilung der Festigkeitseigenschaften von Gusseisen), M. Rudeloff. Giesserei, vol. 13, nos. 33 and 34, Aug. 14 and 21, 1926, pp. 577–584 and 594–598, 20 figs. Method is tried out by which it is possible to determine properties of iron on different parts of casting varying in thickness.

CASTING

Aluminum. The Casting of Aluminum. Brass World, vol. 22, no. 8, Aug. 1926, pp. 255–256. Fundamental requirements necessary to obtain good results; gas or oil furnaces preferred to coke; electric arc not successful because of oxidation.

Bronze Tablets. Casting Bronze Tablets, J. G. Kasjens. Western Machy. World, vol. 17, no. 8, Aug. 1926, p. 360. Points out that careful attention should be given to flask, sand, and every detail of operation.

Centrifugal. Bronze Worm-Gear Blanks Produced by Centrifugal Casting, F. W. Rowe. Inst. Metals—Advance Paper, no. 411, for mtg. Sept. 1–4, 1926, 13 pp., 14 figs.; also abstract in Engineering, vol. 122, no. 3165, Sept. 10, 1926, pp. 338–341, 8 figs. Describes general metallurgical features which obtain in bronze worm-wheel gears cast by various methods and improvements which result from casting these wheels by centrifugal method.

Centrifugal Casting and Its Problems, L. Frommer. Iron Age, vol. 118, no. 9, Aug. 26, 1926, pp. 548–550, 1 fig. Comparisons with sand casting; alloys suited for centrifugal product; phenomena in mold of each process. Translated abstract from Zeit. für Metallkunde, 1925, p. 245.

Cored Work in Iron. Casting Cored in Iron, W. J. May. Mech. World, vol. 80, no. 2065, July 30, 1926, pp. 90–91. Enclosed cores of any kind or shape should always be compressible up to certain stage.

CASTINGS

German Silver. German Silver Castings, Foundry Trade Jl., vol. 34, no. 522, Aug. 19, 1926, p. 168. Copper-nickel-zinc alloy, originally called German silver, is cast with different proportions of various constituents according to its numerous commercial requirements; melting and pouring; texture of molding sand used.

Inspection. Inspecting Castings. Metal Industry (Lond.), vol. 29, no. 8, Aug. 20, 1926, pp. 177–178. Duties of inspector.

Iron. See IRON CASTINGS.

Scabs. Scabs: Their Cause and Remedy, H. S. Newton. Foundry Trade Jl., vol. 34, no. 522, Aug. 19, 1926, p. 167. Explains why vertical face is more susceptible to scabbing than horizontal face; action is due to gases being forced from mold in very similar manner to that of water in whirl, and that gases make their escape at that point of mold where sand is of more open texture; scabbing on brass castings.

Specifications. Tentative Specifications for 88-8-4 Sand Castings. Foundry, vol. 54, no. 17, Sept. 1, 1926, supp. page. Foundry data sheet for physical properties and tests.

Steel. See STEEL CASTINGS.

CENTRAL STATIONS

Avon, Cleveland, O. High Spots in the Design of Cleveland's New Avon Plant. Power, vol. 64, no. 13, Sept. 28, 1926, pp. 466–470, 10 figs. Ultimate capacity of 300,000 kw., two-thirds of which can be accommodated in present building; two units now installed are rated at 35,000 kw. each; width of turbine room is such that future units may be 50,000 kw. if desired; each turbine is equipped with 42,000-sq. ft. single-pass surface condenser; there are four 30,600-sq. ft. double Stirling-type boilers, two arranged to serve each turbine; designed to use bituminous coal; pulverized fuel is used exclusively.

Diesel-Engined. Diesel Engines for Main and Reserve Power Generation in Large Central Stations (Erzeugung von Spitzen- und Ersatzkraft für Ueberland- und Bahnkraftwerke), A. Büchi. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 32, Aug. 7, 1926, pp. 1053–1061, 21 figs. Points out advantages of use of Diesel engines for both main power generation and for reserve power in connection with hydroelectric and steam plants.

A 35,000-Kilowatt Diesel Central Station, C. Wikstrom, Jr. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 556–558, 563 and 569, 4 figs. Typical residential and industrial load of Brooklyn, N. Y., basis for design of metropolitan plant.

Interconnection. Economics of Interconnecting Power Systems (Ueber die Wirtschaftlichkeit der Kuppelung von Grosskraft-Versorgungsgebieten), B. Jansen. Elektrischer Betrieb, vol. 24, no. 7, Apr. 10, 1926, pp. 53–57, 11 figs. Gives calculations, principally graphical, to show saving which can be effected when districts are interconnected, particularly if they contain mixture of hydroelectric and steam-driven stations; presents examples for cases with and without water storage of hydroelectric system, indicating that between 20 and 50 per cent of fuel bill may be saved by interconnection where water storage is possible.

Kearny, N. J. Features of Kearny, N. L. Pollard. Elec. World, vol. 88, no. 9, Aug. 28, 1926, pp. 414–423, 12 figs. Choice of site, arrangement of electrical equipment, control of auxiliaries, 132,000-volt switching, and proposed high-tension transmission, are outstanding features.

Organization of. Building Up an Organization to Operate the New Plant. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 324–325. Finds out that continuity of service is most important thing in power station, and next most important is efficiency.

Parallel Operation. Stability of Parallel Operation in Linking up Large Power Plants (Ueber die Stabilität des Parallelbetriebes beim Zusammenschluss grosser Kraftwerke), L. Dreyfus. Archiv für Elektrotechnik, vol. 16, no. 5, Aug. 2, 1926, pp. 307–330, 12 figs. Discusses overload capacity, danger of resonance and damping; concludes that in parallel operation of synchronous machines over long lines ohmic resistance of machine and line must be taken into consideration, because it can considerably reduce electric damping moment.

Virginia Railway Co. The Virginian Power Plant. Ry. Age, vol. 81, no. 10, Sept. 4, 1926, pp. 419–421, 6 figs. Station at Narrows, Va., is designed to burn powdered "bone" coal to supply steam for a turbo-generator, and to accommodate large variable load. See also Ry. Elec. Engr., vol. 17, no. 9, Sept. 1926, pp. 295–299, 6 figs.; and Elec. Ry. Jl., vol. 68, no. 10, Sept. 4, 1926, pp. 381–384, 5 figs.

CHAINS

Loads. Safe Working Loads for Anchors and Chains (Veilige werkbelasting van sluitings en kettingen), I. R. Mulder. Ingenieur, vol. 41, no. 19, May 8, 1926, pp. 377–380, 3 figs. Discusses load calculation in connection with Dutch standards for anchors or shackles V228 and V229.

Standard. Standard Chains, Eyebolts, and Shackles. Machy. (Lond.), vol. 28, no. 724, Aug. 26, 1926, pp. 613–614, 6 figs. Presents tables for standard chains (single and double), eyebolts and shackles which should be found of value inasmuch as usual tables do not state safe loads.

CHIMNEYS

Concrete, Shell Temperatures. Electrical Determination of Temperatures in Chimney Shells, E. A. Dockstader. Elec. World, vol. 88, no. 8, Aug. 21, 1926, pp. 363–365, 5 figs. Importance of temperature stresses in reinforced-concrete chimneys is emphasized; individual thermocouple circuits give best results; preliminary heat-drop data.

CHUCKS

Gear. Garrison Duplex Gear Chuck Mounted on Indexing Fixture. Am. Mach., vol. 65, no. 15, Oct. 7, 1926, p. 619, 1 fig. Adaptation of standard duplex gear chuck to indexing fixture for purpose of accurately grinding deep holes of relatively small diameter from both ends of automotive gear cluster.

COAL

Carbonization. The Low-Temperature Carbonization of Coal, R. V. Wheeler. Colliery Guardian, vol. 132, no. 3425, Aug. 20, 1926, pp. 405–406, 1 fig. Pehrson process, particular feature of which is that it aims to differentiate between water-forming and oil-forming stages of carbonization of coal, and to provide means for regulating agglutinating properties of highly-caking coals; from economic point of view it makes use of most efficient mode of heat transference, bringing of hot gas into intimate contact with coal; main operations are carried out in two rotary retorts, which are intercommunicating and admit of continuous feed and discharge of material heated.

The Parr Process of Low-Temperature Carbonisation of Coal, W. R. Chapman. Fuel, vol. 5, no. 8, Aug. 1926, pp. 355–361 4 figs. Discusses process invented by S. W. Parr, which was one of earliest in point of time.

Coking. The Carbonization of Coal, J. Roberts. Combustion, vol. 15, no. 3, Sept. 1926, pp. 159–163, 3 figs. Coking and non-coking coals.

The Examination of Coking Coals and Estimation of Their Value, R. Kattwinkel. Fuel, vol. 5, no. 8, Aug. 1926, pp. 347–355, 10 figs. Methods of investigating coking coals—crucible test, distillation behavior, and coking power—and coke density, porosity and friability; Meurice method for determining coking power was modified and new apparatus for this purpose is described.

Combustion. The Combustion of Particles of Coal in Air, H. E. Newall and F. S. Sinnatt. Fuel, vol. 5, no. 8, Aug. 1926, pp. 335–339, 3 figs. Study of cenospheres.

Distillation. Low-Temperature Distillation of Coals. Colliery Guardian, vol. 132, no. 3424, Aug. 13, 1926, pp. 348–349, 2 figs. Details of Crozier process as practiced at Wembley in Crozier retort; process of fractionation is entirely automatic under steady operating conditions; results in considerable reduction in refining costs as compared with older methods of treatment; treatment of bituminous coals.

Pulverized. See PULVERIZED COAL.

COAL HANDLING

Equipment. Solving the Coal and Ash Handling Problem, E. J. Tournier. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 77–87, 27 figs. Modern mechanical equipment for large and small power plants.

Methods. Modern Methods in Coal and Ash Handling, W. W. Sayers. Power, vol. 64, nos. 4, 5, 6, 7 and 8, July 27, Aug. 3, 10, 17 and 24, 1926, pp. 133–136, 169–171, 204–206, 240–241 and 284–286, 35 figs. July 27: Traces progress made in field and emphasizes importance of fuel-handling problem. Aug. 3: Conditions governing selection and application of centrifugal discharge and continuous-bucket elevators, flight and screw conveyors. Aug. 10: Belt conveyors and skip hoists. Aug. 17: Bucket conveyors and storage equipment. Aug. 24: Equipment for crushing coal.

COKE

Quenching. Economic Coke Quenching. Colliery Eng., vol. 3, no. 30, Aug. 1926, pp. 360–361, 1 fig. Novel process of quenching coke by Heller-Bamag system; advantages claimed for process are: production of high-pressure steam by heat contained in incandescent coke; production of water-gas; improvement in quality of coke; production of coke under conditions which are dustless and hygienic; small amount of space required by plant, and low initial and operating costs

The "Heller-Bamag" Coke-Quenching Process. Iron & Coal Trades Rev., vol. 113, no. 3049, Aug. 6, 1926, p. 193, 1 fig. Particulars of new process known as Heller-Bamag system, in which quenching is done in steam-tight, coke-quenching chamber by spraying with highly superheated steam.

COKE OVENS

Coking Heat. Determination of Heat Consumption in Coking Process (Bestimmung des Wärmeverbrauches bei der Verkokung), C. Still. Glückauf, vol. 62, no. 15, Apr. 10, 1926, pp. 453–458. Points out that use of heat balances in most cases are inaccurate and inexpedient, because heat of degasification is usually overlooked, causing errors up to 50 per cent of actually required coking heat; only practical method of determining required coking heat is direct measurement of heating-gas consumption by means of gas meter.

United States. The Present Status of Coke-Oven Industry in the United States (Der gegenwärtige Stand des Kokereiwesens in den Vereinigten Staaten), H. Niggemann. Glückauf, vol. 62, nos. 23 and 24, June 5 and 12, 1926, pp. 729–740 and 701–770, 10 figs. Bee-hive ovens; coke ovens and by-product recovery, types of ovens, including Koppers, Becker, Wilputte, Roberts and Semet-Solvay; coke-oven practice; benzol recovery; tar distillation; water-gas regenerators; superiority of American plants.

COMBUSTION

Chemistry. Unusual Features of Combustion Chemistry, R. T. Haslam and J. T. McCoy. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, pp. 941–942, 2 figs. Hydrogen in fuel explains variation of CO_2 and O_2 in flue gas with changes in excess air.

Control. An Essential Principle for Scientific Boiler Firing (Un principe essentiel pour la conduit scientifique des combustions industrielles), M. Bouffart. Chaleur & Industrie, vol. 7, no. 76, Aug. 1926, pp. 437–442, 1 fig. Discusses theory of combustion of coal excess or deficiency of air; air supply and incombustibles; combustion of gas in blast furnaces, etc.

Automatic Combustion Control, J. F. Cassell. Gas Age-Rec., vol. 58, no. 9, Aug. 28, 1926, pp. 279–280 and 284, 7 figs. Results of study of various types of automatic combustion controls.

Surface. Surface Combustion and Its Influence on the Future Economics of Heat and Power, T. G. Tulloch. Chem. & Industry, vol. 45, no. 33, Aug. 13, 1926, pp. 280T–285T, and (discussion) 285T–287T Economies of surface combustion.

CONDENSERS, STEAM

Failures. Failure of Modern Condensers, F. J. Drover. Indus. Mgmt. (Lond.), vol. 13, no. 9, Sept. 1926, pp. 404 and 406. Considers causes of condenser failure, which in practically every case is due to failure of tubes and ferrules; and methods adopted to prevent, or at least greatly lessen chances of serious breakdown.

Surface. Testing a Surface Condenser in Action, Chas. E. Colborn. Power, vol. 64, no. 12, Sept. 21, 1926, pp. 431–433, 6 figs. To secure maximum performance, continuous check is necessary, not only to detect unusual conditions, such as air leaks, but to assist in forecasting probable need for cleaning of condenser tubes; suggestions for making condenser tests.

CONDUITS

Pressure. Determining Maximum Economic Dimensions of Metal Pressure Conduit (La Solution générale du Problème de la Détermination des Dimensions Economiques Maximum d'une Conduite forcés en Métal et son Application aux Calculs pratiques), P. Santo Rini. Houille Blanche, vol. 25, no. 200, May-June 1926, pp. 65–71. Calculation of discharge, diameter, coefficient of roughness in riveted and welded pipe, effect of water hammer, etc.; gives examples.

CONNECTING RODS

Forks. Connecting-rod Forks, T. Petty. Engineer, vol. 142, no. 3588, Sept. 17, 1926, pp. 312–313, 1 fig. Describes simple form for forked connecting-rod end which is easily machined, and rapid method for its design, character of which is synthetic as opposed to tentative and analytic process.

CONVEYORS

Monorail Runways. Arch Beam Monorail Runway. Iron Age, vol. 118, no. 115, Oct. 7, 1926, p. 1003, 3 figs. Monorail track made up of combination of standard rolled products to meet requirements of overhead conveying system developed by Cleveland Crane & Engineering Co., Wickliffe, O.; supporting beam and rail combined in one unit.

COÖPERATIVE SOCIETIES

Coöperative Work Shops. Coöperative Workshops in the United States. Monthly Labor Rev., vol. 23, no. 2, Aug. 1926, pp. 23–27. Present study represents first attempt at inclusive study of workers' productive societies.

COPPER ALLOYS

Ampco. Characteristics of Ampco Metal. Am. Mach., vol. 65, no. 9, Aug. 26, 1926, p. 377. Reference-book sheet. Ampco is copper-aluminum alloy containing appreciable percentage of iron; nature of alloy; machining; forging and welding.

Copper-Magnesium. Preliminary Experiments on the Copper-Magnesium Alloys, W. T. Cook and W. R. D. Jones. Inst. Metals—Advance Paper, no. 410, for mtg. Sept. 1–4, 1926, 14 pp., 13 figs. Account of preliminary experiments of research; chief feature is production of sound chill-cast bars free from smooth-sided internal gas cavities by means of double-melting process, similar to that recently recommended by Archbutt for production of castings in aluminum free from pinholes; details of method adopted and type of bottom-pouring crucible used to eliminate inclusions of flux and slag; properties of chill-cast bars containing up to 10 per cent copper.

Copper-Zinc. Segregation Phenomena in Copper-Zinc Alloys (Zur Kenntnis der Seigerungserscheinungen bei Kupfer-Zinklegierungen), W. Claus. Zeit. für Metallkunde, vol. 18, no. 7, July 1926, pp. 228–230, 4 figs. New experimental arrangement for determination of segregation phenomena, intercrystalline ingot segregation of copper-zinc alloys with more than 35 per cent copper; confirmation of reversed ingot segregation, found and explained by Jokibe and Masing, of a copper-zinc alloy with 15 per cent copper; examples of technical copper-zinc alloys with 60 to 70 per cent copper which show reversed segregation.

CORE OVENS

Heat Economy in. Thermotechnology of a Core-Drying Oven (Die Wärmetechnik eines Kerntrocken-

ofens), Schlipköter. Giesserei, vol. 13, no. 35, Aug. 28, 1926, pp. 648–650, 3 figs. Results of tests show that it is not so important to maintain a high temperature as to provide for an intensive air circulation in closed oven; by heating method described, 30 to 40 per cent of gas, as compared with volume formerly consumed, was saved; by installing temperature-measurement equipment in pipe foundries, which records exhaust-gas temperature of each core oven, a daily saving of 30,000 to 40,000 cu. m. of gas can be effected.

CORES

Drying. Thermotechnical Investigation of Core-Drying Plant of Firm of Carl Schenck, Darmstadt, Machine Shop and Iron Foundry (Wärmetechnische Untersuchung der Kerntrockenanlage der Firma Carl Schenck, Darmstadt, Maschinenfabrik und Eisengiesserei G.m.b.H.), Borissow. Giesserei, vol. 13, no. 35, Aug. 28, 1926, pp. 650–662, 35 figs. Results of tests on plant with Voith system of circulating air, equipped with ventilator, electric motor, cool-water piping, air-pipe lines, valves and nozzles; time required for drying cores, weight loss with drying in relation to time, and temperature within core.

Overhanging. Setting Overhanging Core Simplified Through Practical Methods, H. N. Tuttle. Foundry, vol. 54, no. 17, Sept. 1, 1926, pp. 691–693, 8 figs. Overhanging core is name usually applied to core where print overhangs or projects beyond body of core; methods of setting these difficult cores

CORROSION

Iron and Steel. The Corrosion and Rusting of Steel and Cast Iron (Recherches sur la corrosion et l'enrouillement de l'acier et de la fonte), R. Girard. Revue de Métallurgie, vol. 23, nos. 6 and 7, June and July 1926, pp. 361–367 and 407–417, 33 figs. June: Action of weak acid solutions on ferrous metals. July: Action of saline solutions.

COST ACCOUNTING

Free Competition and. Knowing the Cost and Making the Price, N. B. Gaskill. Indus. Mgmt. (N. Y.), vol. 72, no. 3, Sept. 1926, pp. 141–145. Author points out that greater part of conflict between business and law and in business world itself can be traced to almost universal disregard of cost in fixing selling price and efforts which this practice necessitates either to overcome its effects or prevent its use; price fixing for self-preservation; price cutting without relation to cost; a minimum price based upon known cost.

CRANES

Design. Tendencies of Modern Crane Design, E. G. Diegehen. Mech. World, vol. 80, nos. 2063 and 2065, July 16 and 30, 1926, pp. 47–48 and 85–86. Introduction of electric drive; wire ropes; improved materials. Review of recent developments indicates increasing tendency to adapt crane to its job and its environment, rather than to subordinate process to limitations of standard types of crane.

Floating. A 200-Ton Floating Crane. Engineer, vol. 142, no. 3588, Sept. 17, 1926, p. 315, 2 figs. partly on p. 308. Constructed by Werf Gusto, Schiedam, Holland, for Port of Le Havre; designed to hoist load of 200 tons to height of 16 ft. above water line, at radius of 95 ft. from center of crane, and load of 150 tons at distance of 130 ft.

Hammer-Head. Calculation of a Hammer-Head Crane of 150 (200) Tons Capacity (Berechnung eines Hammerkrans von 150 (200)t Tragfähigkeit), J. M. Bernhard. Praktischer Maschinen-Konstrukteur, vol. 59, nos. 23–24 and 25–26, June 12 and 26, pp. 238–245 and 262–266, 16 figs. Discusses various types of stationary cranes; develops calculations of most economic hammer-head type for given purpose; counterweight, radius of action; pressure on supports, supporting frame, foundations, loads, etc.

Traveling. Traveling Cranes for Handling Freight Cars in Railway Terminal Yards, H. B. Dwight. Elec. Jl., vol. 23, no. 9, Sept. 1926, pp. 448–450, 3 figs. Method of moving long string of cars by means of cranes allows cars in most congested parts of yard to be taken out as easily as those on outside parts of yard and gives complete freedom in order in which cars are made up into train.

CUPOLAS

Rein. The "Rein" Cupola. Machy. Market, no. 1344, Aug. 6, 1926, p. 23, 3 figs. Although in use for over twenty years, it is claimed to embody all most modern developments in construction; in designing. Rein cupola, low-lying, well-confined melting zone with correct tuyere dimensions, incline, position and level were aimed at; loss of iron during melting process is claimed to be practically eliminated.

CUTTING METALS

Jet-Cutting Machines. Jet-Cutting Machines. Machy. (Lond.), vol. 28, no. 722, Aug. 12, 1926, pp. 541–544, 6 figs. Application of machines, using jet of oxygen as cutting medium to railway-car building.

Mechanical and Autogenous. Comparison Between Mechanical and Autogenous Cutting (Mechanisches und autogenes Schneiden, ein Vergleich), P. Kämpf. Maschinenbau, vol. 5, no. 15, Aug. 5, 1926, pp. 702–704, 5 figs. Cutting in cold and in hot state; comparison on basis of energy consumed in kilowatt and time in minutes per meter of length; results are given in curves.

Vibroshear Machine. "Vibroshear" Sheet-Metal-Cutting Machine, C. F. R. Giesler. Mech. World, vol. 80, no. 2065, July 30, 1926, p. 80, 2 figs. Machines for cutting steel, copper, brass, lead and other metal sheets.

CUTTING TOOLS

Coolants. Coolants as Aids to Cutting Tools, S. French. Am. Mach., vol. 65, no. 9, Aug. 26, 1926, pp. 381–382. High-speed removal always requires coolants; effects of heating; qualities of coolants; dangers of separation of ingredients.

CYLINDERS

Heat Stresses. Heat Stressed State of and Isotropically Elastic Cylinder, G. H. Masloff. Vestnik Engenerov (Messenger of Eng.), no. 56, May-June 1926, pp. 258–261, 3 figs. Investigation of temperature stresses in cylinders when temperature is not uniform throughout body but varies in accordance with certain law applied to case of cylinder. (In Russian.)

D

DIE CASTING

Brass and Bronze Work. Conflicting Foundry Methods, J. G. Kaiser. Brass World, vol. 22, no. 8, Aug. 1926, pp. 263–264. Manufacturer of special foundry equipment presents arguments in favor of new machine for making die castings for brass and bronze work.

DIESEL ENGINES

Airless-Injection. Compressorless Fuel Injection (Ueber die Mittel zur kompressorlosen Brennstoffeinspritzung), G. Eichelberg. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 32, Aug. 7, 1926, pp. 1079–1089, 43 figs. Requirements of fuel injectors; behavior of fuel-injection devices with regard to these requirements; indirect injection with accumulation.

Investigations of the Self-Ignition of Liquid Fuels (Untersuchungen über die Selbstzündung flüssiger Brennstoffe), K. Neumann. Zeit. des Vereines deutscher Ingenieure, vol 70, no. 32, Aug. 7, 1926, pp. 1071–1078, 19 figs. Phenomena occurring with injection of heavy oil in a highly heated chamber are experimentally and mathematically investigated, and results applied to compressorless Diesel engines.

Design. New Tendencies in Diesel-Engine Design (Neueste Bestrebungen im Bau von Dieselmotoren), F. E. Bielefeld. Schiffbau, vol. 27, nos. 11, 12 and June 2, 16 and July 7, 1926, pp. 313–316, 341–346 and 365–368, 50 figs. Discusses various attempts to reduce cost of fuel consumption of Diesel engines, in particular, elimination of compressor, use of unconventional cycles, such as compounding, and attempts to burn solid fuels; one method of reducing heat losses is by increasing number of revolutions; another way lies in direction of compounding; in Bielefeld experimental compound Diesel, high-pressure piston runs at speed 18 times as high as does low-pressure piston, whereby losses to cooling water and exhaust are materially decreased; pulverized-fuel engine developed by R. Pawlikowski, former collaborator with Diesel; refers to some very unconventional types of engines. July 7: Devices intended to secure rapid combustion; considers use of catalysts, and varying conditions of injection at different loads.

Deutz. First Deutz-License Engine for Ice Plant. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 568–569, 1 fig. Vertical unit with airless injection and normal combustion space placed in service by Lansdale Ice & Storage Co., Perkasie, Pa.

Dragline Excavator. Dragline Excavator with Diesel Engine. Engineering, vol. 122, no. 3165, Sept. 10, 1926, pp. 324–326, 7 figs. Details of Diesel engine developed by Northwest Engineering Co. of Chicago, based on experimental work extending over several years; it is of solid-injection type and has four cylinders.

Foundations. Good Foundations Best Diesel Insurance, J. J. McDougall. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 1005–1005, 7 figs. Points out that light, poorly constructed foundations endanger all parts of engine.

Heavy-Oil. Development of Heavy-Oil Engines and Their Applications (L'evolution des moteurs à huile lourde et leurs applications), A. Veranneman. Technique Moderne, vol. 18, no. 15, Aug. 1926, pp. 449–460, 23 figs. Discusses advantages and disadvantages of various types; results of tests; efficiency and fuel consumption, including 4-stroke and 2-stroke engines, pneumatic and mechanical injection, semi-Diesels, and Still engine; heat recovery; marine Diesels, tractors, locomotives, etc.

High-Power Machines. Single- and Double-Acting Four- and Two-Stroke Diesel Engines as High-Power Machines (Einfach- und doppeltwirkende Viertakt- und Zweitakt-Dieselmotoren als Grosskraftmaschinen), M. Gercke. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 32, Aug. 7, 1926, pp. 1062–1069, 8 figs. Development of Diesel engines for ship propulsion and drive of electric plants; space required for Diesel engines; economic factors and conclusions; future tasks and prospects.

Large. Large Diesel Engines, R. Johnstone-Taylor. Gas & Oil Power, vol. 21, no. 252, Sept. 2, 1926, pp. 263–264, 3 figs. Recent progress and research; details of Nobel and M.A.N. engine, and British design brought out by Richardsons Westgarth; engine of the future.

Logging Equipment. Largest Oil-Engined Logging Drum Commissioned. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 541–544, 4 figs. Long Bell Lumber Co. uses 150-hp. Diesel yarding engine; summarizes advantages of Diesel-equipped logging machinery.

Oil-Vapor Extraction. A Diesel Engine Oil Vapor Extractor. Mar. News, vol. 13, no. 4, Sept. 1926, pp. 60 and 67, 4 figs. Recently perfected apparatus recovers large portion of lubricating oil and prevents pollution of engine-room atmosphere.

Solid-Injection. Boiler Fuel in the Solid Injection Engine, D. W. Dickie. Pac. Mar. Rev., vol. 23, no. 8, Aug. 1926, pp. 356–357, 1 fig. Heretofore experiments made by writer to get solid-injection engine to run on boiler fuel have been based upon theory that viscosity of boiler fuel was cause of trouble; this theory was entirely exploded by heating boiler fuel; steam-turbine nozzle experimenters threw light on subject of flow of steam through nozzles and clew may possibly be obtained from their work.

Temperature Stresses. Tests Explode the Myth of Excessive Temperature Stresses in Diesels. Power, vol. 64, no. 12, Sept. 21, 1926, pp. 438–440, 6 figs. Temperature distribution in cylinder walls based on volume and time; temperature stresses at starting and during operation; temperature measurements in Sulzer 2-stroke-cycle marine engine. Reported by Sulzer Bros., Winterthur, Switzerland.

Vibrations. Some Experiences with Torsional Vibration Problems in Diesel Engine Installations, J. F. Fox. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 3, Aug. 1926, pp. 695–719, 21 figs. Problems involving torsional vibration which have been encountered by New York Navy Yard.

Waste-Heat Utilization. Use of Waste Heat from Diesel Engines. Oil Eng. & Technology, vol. 7, no. 123, July 1926, pp. 301–302, 2 figs. Describes Diesel engine plant of King's College Hospital; economic combustion of boilers receives considerable aid from exhaust gases of Diesel engines by passing gases through air heater in which air to furnaces is preheated to about 20 deg. fahr.; further saving is effected by utilizing cooling water from cylinder jackets of Diesel engines.

Worthington. The Worthington Double-Acting Two-Stroke Diesel Engine. Engineering, vol. 122, no. 3166, Sept. 17, 1926, pp. 349–352, 4 figs. Reviews work done with engine of Worthington Pump & Machy. Corp., Buffalo, N. Y.; results of severe tests to demonstrate its reliability.

DIVIDING MACHINES

Circular. Investigating a Circular Dividing Machine (Untersuchungen an einer Kreisteilmaschine), L. Fritz. Zeit. für Instrumentenkunde, vol. 46, no. 6, June 1926, pp. 289–320, 11 figs. Describes dividing machine of Geodetic Institute of Technical High School at Hannover; illumination, microscopes, axial rotation, formation of rosettes, improvement in diameter, systematic and accidental errors, etc.

DRILLING MACHINES

Boiler-Plate. Multiple Boiler Plate Drilling Machine. Boiler Maker, vol. 26, no. 8, Aug. 1926, pp. 234–235, 2 figs. Heavy-type plate and rivet-hole drilling machine specially designed for boiler, tank, and structural shops, constructed by Cincinnati Bickford Tool Co., Ohio.

Index Plates. A Machine for Drilling Index Plates, M. Wright. Am. Mach., vol. 65, no. 9, Aug. 26, 1926, p. 369. Automatic drilling machine for drilling circles of holes in index plates for dividing heads.

Radial. 7-ft. Universal Portable Radial Drilling and Tapping Machine. Machy. (Lond.), vol. 28, no. 724, Aug. 26, 1926, p. 615, 2 figs. Supplied by W. Asquith, Halifax, for work in locomotive shops; it is largest portable universal machine yet constructed by firm.

DROP FORGING

Process. The Drop Forging Process, J. H. G. Williams. Am. Soc. Steel Treating—Trans., vol. 10, no. 3, Sept. 1926, pp. 409–435, 10 figs. Describes entire process of drop forging from inspection of raw materials to finished products; estimate of cost of producing certain types of drop forging.

DYNAMOMETERS

Recording. Direct Indicating Power Meter (Direkt zeigender Kräftemesser), F. Bergtold. Zeit. für Instrumentenkunde, vol. 46, no. 3, Mar. 1926, pp. 143–148, 8 figs. Describes dynamometer for determining small forces such as peripheral forces in an electric meter; based on gravity, without use of springs; gives very small error.

E

ECONOMIZERS

Mild-Steel. Mild-Steel Economizers (Schmiedeeiserne Vorwärmer), R. Schirmer. Wärme, vol. 49, no. 30, July 23, 1926, pp. 532–534, 9 figs. Points out that under proper conditions, which can easily be maintained in modern stations, mild-steel economizers are not subject to corrosion or formation of deposits; from point of view of heat transmission and mechanical strength, mild steel is far superior to cast iron and much more desirable material for economizers of high-power, high-pressure boilers; gives desirable conditions of operation; describes Humboldt mild-steel economizers which consist of loops of seamless tubing expanded into seamless header tubes, and arranged for easy and complete access for cleaning. See translated abstract in Power Engr., vol. 21, no. 246, Sept. 1926, p. 352.

ELECTRIC WELDING

Arc. See ELECTRIC WELDING, ARC.

Spot. New Method of Spot Welding, R. G. Hudson. Elec. World, vol. 88, no. 8, Aug. 21, 1926, p. 375, 2 figs. Pin-type welding is developed to meet need for improvement over riveted and spot-welded joints.

ELECTRIC WELDING, ARC

Mining, in. Electric Arc Welding in Mining (Die elektrische Lichtbogenschweissung im Bergbau), H. von Neuenkirchen. Glückauf, vol. 62, no. 24, June 12, 1926, pp. 770–773, 9 figs. Discusses numerous appli-

cations in and about coal mines, and savings made possible by use of this process; repair work and new constructions are cheapened, and it is possible to repair parts which would otherwise be scrapped; among examples of application are building of structural-steel frames, building up of wheel flanges, repair of broken castings, welding of pipe lines, filling of corroded spots on boiler plates, repairs to connecting rods, etc. See brief translated abstract in Colliery Eng., vol. 3, no. 30, Aug. 1926, p. 376.

Penetration. Factors Affecting Penetration, J. B. Green. Welding Engr., vol. 11, no. 8, Aug. 1926, pp. 28–31, 3 figs. Study of penetration in metallic arc welding becomes simplified when it is considered in terms of heat.

Structural Steel. Electric Arc Welding Steel Structures, J. B. Abell. Elec. Light & Power, vol. 4, no. 9, Sept. 1926, pp. 21–23, 48 and 54, 5 figs. Application of arc welding to new two-story and basement commercial building for Peerless Auto Sales Co. in Canton, Ohio.

Electric Welding Steel Structures. Gen. Elec. Rev., vol. 29, no. 9, Sept. 1926, pp. 33–34. Tests prove superiority of welded over riveted connections; effort to amend building codes.

Tests of Arc Welded Structural Steel, A. M. Candy and G. D. Fish. Iron & Steel Engr., vol. 3, no. 8, Aug. 1926, pp. 380–384B. Describes series of test specimens which were all welded with various members located in same position and manner as would be required if various members were actually part of building structure.

ELECTRICITY SUPPLY

Developments. The Present and Future Development of Electricity Supply, J. F. C. Snell. Engineering, vol. 122, no. 3161, Aug. 13, 1926, pp. 194–198. Historical review of developments and future prospects. Presidential address to Sect. G of Brit. Assn.

ELEVATORS

Brakes. Operation and Adjustment of A.-C. Elevator Brakes, H. B. Cook and F. A. Annett. Power, vol. 64, no. 10, Sept. 7, 1926, pp. 366–370, 9 figs. Problems involved in obtaining satisfactory a.c. elevator brakes; operation and adjustment of three different designs.

ENGINEERS

Changing Status of. The Changing Status of the Engineer, F. B. Jewett. Engrs'. Bul., vol. 10, no. 8, Aug. 1926, pp. 3–6. How twentieth century conditions are altering his relations to his profession, to industry, and to society.

EXHAUST STEAM

Textile Mills. The Use of Exhaust Steam for Process Work in Textile Plants, S. M. Green. Engrs. & Eng., vol. 43, no. 6, June 15, pp. 160–164, 2 figs. Details of recent installation of 3500-kw. turbine and its performance.

F

FIREBRICK

Strength of Texture. A Comparison of the Uniformity of Strength and Texture of Fire Brick Made by Different Processes, A. E. R. Westman and W. H. Pfeiffer. Am. Ceramic Soc.—Jl., vol. 9, no. 9, Sept. 1926, pp. 626–632, 1 fig. Of brands examined, those made by stiff-mud process are found to be more uniform in strength and less uniform in structure than those made by dry-press process.

FITS

Shrink. Calculation of Shrink Fits (Beitrag zur Berechnung von Schrumpfverbindungen), W. Janicki. Schweizerische Bauzeitung, vol. 88, no. 6, Aug. 7, 1926, pp. 93–97, 4 figs. Describes two methods of calculating allowance for shrink fits of narrow bands or collars, and broad bands or rings and develops equations for purpose.

FLIGHT

Long-Distance. Long-Distance Flying, A. Cobham. Roy. Aeronautical Soc.—Jl., vol. 30, no. 188, Aug. 1926, pp. 482–491 and (discussion) 492–494. Author discusses two main types of long-distance flying, firstly, long non-stop flights, and secondly, long flying journeys where many landings are made.

FLOW OF AIR

Pitot Tube. The Pitot Tube, J. H. Roberts. Colliery Eng., vol. 3, nos. 28 and 29, June and July 1926, pp. 246–247 and 292–294, 10 figs. Discussion of pitot tube and its theory, and application to measurement of flow of air in mines.

FLOW OF FLUIDS

Nozzles. Eddying Flow From Annular Nozzles, E. Tyler and E. G. Richardson. Lond., Edinburgh, & Dublin Philosophical Mag. & Jl., of Science, vol. 2, no. 8, Aug. 1926, pp. 436–447, 8 figs. Points out that conclusions of Krüger and Marschner on frequency of eddies produced in flow from annular slits require modification; present authors claim to show that motion once started is governed by diameter of disk, modified by width of slit, when latter is small; there is critical velocity for commencement of eddying flow, which is governed by slit; but little above this, at another critical velocity, pendulation is governed by size of disk.

FLOW OF GASES

Measurements. Measurements in the Marginal Layer of Flowing Gases (Messungen in der Grenzschicht strömender Gase), W. Ludowici. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 34, Aug. 21, 1926, pp. 1122–1124, 7 figs. Describes apparatus and measuring devices for experimental determination of flow and temperature conditions in marginal layer of flowing gases.

Measuring Flow of Air and Gas with Special Reference to Dynamic Principle (Die Messung strömender Luft un Gase unter beosnderer Berücksichtigung des dynamischen Messprinzips), O. Mattner. Chemiker-Zeitung, vol. 50, nos. 72 and 76, July 21 and Aug. 4, 1926, pp. 533–534 and 574–576, 13 figs. Methods of measuring orifices and nozzles which have given satisfactory results in practice, including measurement of pressure (Nipher for static, Krell, etc., for dynamic); measurement of velocity and volume (Brabée, Prandtl, etc.); measuring instruments, portable and fixed.

FLOW OF WATER

Measurements. Flow Measurements with the Flat Plate Orifice. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 997–1000, 6 figs. Simplified formulas and coefficients facilitate use of flow meter for temporary, or portable meter; use in air; steam and water measurement.

Pipes. Determining Pressure Losses in Pipe Lines (Sulla determinazione delle perdite di carico nelle tubazioni), Gino Bozza. Giornale di chimica Industriale ed Applicata, vol. 8, no. 7, July 1926, pp. 370–374, 3 figs. Discusses rational bases for determining losses in conduit and describes simple method of graphic calculation based on results of Lang.

Experimental Determination of Coefficient of Discharge of Pipes (Détermination expérimentale du coefficient de débit des tuyères fonctionnant en écoulement libre), Rateau, Leroux and Bourgeat. Académie des Sciences—Comptes Rendus, vol. 185, no. 4, July 26, 1926, pp. 259–266, 6 figs. Experiments with bronze pipes of 1 to 8-cm. diameters and different charges, showing increase of discharge with diameter of pipe, variation of discharge jet, effect of temperature, etc.

FORGE SHOPS

Safety Work in. Safety Work in the Drop Forge Shop, G. A. Kuechenmeister. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, pp. 284–288, 4 figs. Points out that enforcement of safety rules and complete data on equipment may result in material reduction of accidents; board-hammer pulley catchers.

FORGING

Brass. An Outline of the Methods Used in Forging Brass, F. W. Curtis. Am. Mach., vol 65, no. 10, Sept. 2, 1926, pp. 393–396, 10 figs. Characteristics of metal and shapes that can be forged; temperatures necessary for best results; types of dies; important points to be considered.

Temperature, Effect of. The Effect of Temperature in Forging, H. Brearley. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, pp. 290–292 and 295, 4 figs. Improper heating of steel for hot working is frequently responsible for introduction of serious mechanical defects in finished product.

Upsetting. Upsetting Places Fibers in Compression not Tension, C. D. Harmon. Iron Trade Rev., vol. 79, no. 10, Sept. 2, 1926, pp. 574–575, 6 figs. Deals with action of steel when upset in modern forging machine.

FOUNDRIES

Brass. See BRASS FOUNDRIES.

Merchandising Policy. Better Merchandising is Need of American Foundry Industry, S. W. Utley. Iron Trade Rev., vol. 79, no. 12, Sept. 16, 1926, pp. 709–711 and 714. Author shows that faulty merchandising is responsible for many of ills of foundry industry and that sacrificing profit in interest of increasing output is almost business suicide.

Rate Setting. Rate Fixing and Estimating in Foundries (Neuzeitliche Kalkulation in Giessereien), T. Weber. Giesserei, vol. 13, no. 23, June 5, 1926, pp. 416–418, 2 figs. Gives example showing advantage of piece-work rate setting over estimation based on total working time.

Steel. Savings Results from Pre-Heating. Iron Age, vol. 118, no. 12, Sept. 16, 1926, pp. 759–762, 6 figs. Mechanical reclaiming of foundry sand, use of electricity for annealing steel castings in annealer of unique design, preheating of scrap before it is charged into electric melting furnace, and baking of cores electrically are features of practice of Industrial Steel Casting Co., Toledo, Ohio.

Time Study and Wages. Calculation of Piece-Work Rates Based on Time Studies in the Foundry (Aufbau der Stücklöhne auf Grund von Zeitstudien in der Giesserei), H. Tillmann. Stahl u. Eisen, vol. 46, no. 34, Aug. 26, 1926, pp. 1149–1154, 5 figs. Nature and importance of time studies; difference between work and time studies; influence of fatigue; numerical evaluation for determination of piece-work wages.

Time Studies in the Foundry (Methodik der Zeitstudien in der Giesserei), H. Tillmann. Giesserei, vol. 13, nos. 12, 13 and 14, Mar. 20, 27 and Apr. 3, 1926, pp. 233–238, 249–252 and 269–273, 14 figs. Investigations on conducting of time studies, especially on molding machines, and their utilization.

Time Study for the Molding of a Disk Clutch (Zeitstudie für das Formen einer Scheibenkupplung), H. Tillmann. Giesserei, vol. 13, no. 22, May 29, 1926, pp. 398–400, 2 figs. Describes how time was reduced from 13 to 10 minutes by proper application of time and work studies.

Variety of Products. Variety of Product a Factor in Success, R. Micks. Can. Foundryman, vol. 17, no. 8, Aug. 1926, pp. 5–6, 3 figs. Methods and equipment of foundry of Gilson Mfg. Co., Guelph, Ont.; products include gas and gasoline engines, pipe and pipeless furnaces, heaters, washing machines, farm machinery, revolving and tilting chair fixtures; oil is principal binder used and it is claimed to have many advantages over other binders.

FOUNDRY EQUIPMENT

Loading Device for Mixers. Loading Device for Foundry Mixers. Iron Age, vol. 118, no. 14, Sept. 30, 1926, p. 931, 1 fig. Air-operated device known as Simplex loader, for use in connection with mixers, placed on market by Scully-Jones & Co., Chicago.

Mixers. Blast Furnace Metal Mixer Adapted for Foundry Use, H. Illies and A. Hesse-Wortmann. Foundry Trade Jl., vol. 34, no. 521, Aug. 12, 1926, pp. 131–132, 2 figs. Oil-fired 25-ton mixers with flat hearths operated in large pipe foundry in Germany; they are tilted hydraulically and receive all iron that arrives from blast furnaces; in case blast furnace furnishes insufficient metal, cupola iron is added, and any quantity can be tapped at desired time.

Mixer is Mounted on Roller Gears. Iron Trade Rev., vol. 79, no. 14, Sept. 30, 1926, p. 847, 1 fig. Mixer of circular inactive type, constructed by Wellman Smith Owen Engineering Corp., London, was installed in Thomas steel plant of Ougée-Marihaye Co. at plant near Liége; it handles molten pig iron amounting to upward of 1500 tons per day; charging, pouring, and slagging spouts are provided; served by two 50-ton electrically operated ladle cranes.

Sand Mixer. A New Mixing Apparatus for Molding Sand (Eine neuartige Formsandaufbereitungsanlage), H. Behrens. Giesserei, vol. 13, no. 23, June 5, 1926, pp. 413–416, 8 figs.; also translated abstract in Foundry Trade Jl., vol. 34, no. 522, Aug. 19, 1926, p. 154, 3 figs. New apparatus, known as "Eirich" patent, consisting of bottom plate rotating around vertical axis and runner with two scrapers moving around axis in opposite direction; table and runner can be regulated to any vertical distance.

FURNACES, HEAT TREATING

Hardening. Gas-Fired Hardening Furnaces Insure Accurate Temperature Control, J. A. Cameron. Iron Trade Rev., vol. 79, no. 12, Sept. 16, 1926, pp. 712–713, 4 figs. Gas-fired furnaces used in making of machines manufactured by Cameron Machine Co., combining new type of burner and method of radiation.

FURNACES, HEATING

Gas-Fired Rivet. Rivet Heating in Gas-Fired Furnaces, J. L. Munnis. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, p. 295, 1 fig. Details of furnace used in large box-car plant.

Mechanical Firing. Heating Furnace Fired Mechanically, C. H. Lawrence. Iron Trade Rev., vol. 79, no. 12, Sept. 16, 1926, pp. 720 and 723, 2 figs. Stoker-operated billet-heating furnace at plant of Elyria Iron & Steel Co., Elyria, Ohio.

G

GAGES

Slip. Slip Gauges. Indus. Mgmt. (Lond.), vol. 13, no. 9, Sept. 1926, pp. 407–408. Deals with slip or combination block gage system of measurement.

GAS PRODUCERS

Progress In. Progress in Gas-Producer Practice. Colliery Eng., vol. 3, nos. 28 and 29, June and July, 1926, pp. 277–279 and 327–329, 9 figs. Automatic charging, mechanical agitators, and automatic ash removal discussed.

GASES

Measurement of Large Quantities. Industrial Measuring of Large Quantities of Gas (Mesure industrielle des grands débits gazeux), M. Laffargue. Chaleur & Industrie, vol. 7, no. 76, Aug. 1926, pp. 425–428, 3 figs. Discusses measurement of large quantities of gas, several 1000 cu. m. per hour, measuring speed, not volume; describes simple and effective apparatus for purpose, based on direct measurement of gas flow by means of calibrated pitot tube.

GEAR CUTTING

Helicoidal. Field of Application and of Helicoidal Process for Cylinders (Arbeitsbereich und Vielseitigkeit des Abwälzverfahrens für zylindrische Körper), Werkstattstechnik, vol. 20, no. 14, July 15, 1926, pp. 441–446, 25 figs. Discusses range of helicoidal milling cutters of modulus 0.2 to 30, from smallest to 4000-mm. diameter of wheel; automobile gears, reduction gears for turbines.

GEARS

Automobile. Gear-Steels and the Production of Automobile Gears, J. Bethune and W. G. Hildorf. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 422–428, 12 figs. Outline of practice of producing gears used by Reo Motor Car Co., Lansing, Mich., and new method for cutting rear-axle drive pinion by using two machines, each machine cutting one side of teeth; explains why this method is not only cheaper but produces gears of higher quality; results of experiments with transmission gears indicate that, to get greatest degree of quietness, every effort should be made to increase number of teeth in contact and to improve profile and tooth spacing; discusses various kinds of gear steel, together with heat treatments which have given good results.

Cast-Iron, Repairing. Repairing a Cast-Iron Gear, Discussion, E. Andrews. Am. Mach., vol. 65, no. 11, Sept. 9, 1926, pp. 454–455, 4 figs. Discussion of article by O. P. Williams published in same journal, vol. 63, p. 586. Modern welding methods have shown that welding in or building up gear teeth, give homogeneous structure that may easily be machined and which possess degree of strength equal to that of original section.

Chain-Driven. A Continuously-Variable, Chain-Driven Change-Speed Gear. Engineer, vol. 142, no. 3685, Aug. 27, 1926, pp. 220–222, 8 figs. Positive, infinitely variable gear, manufactured by P.I.V. Gear Syndicate; it has been applied in bakery, confectionery, and biscuit-making industries and in connection with manufacture of cement, paper, electric cables, cotton, and artificial silk.

Helical. Solving a Helical Gear Problem by Unconventional Methods, H. J. Eberhardt. Am. Mach., vol. 65, no. 15, Oct. 7, 1926, p. 588. Reference to article by E. Buckingham in same journal, Aug. 19, 1926, p. 327, for solving problem of cutting helical gear of small helix angle on hobbing machine equipped with synchronized gear trains; procedure ordinarily followed for Newark gear-hobbing machine would be to find minimum helix angle to just meet two adjacent teeth; normal pitch hobs are used; chief advantage is fact that with this method machine will cut actual gear desired.

Hypoid. New Packard Line Employs Hypoid Gears in Rear Axle, L. S. Gillette Automotive Industries, vol. 55, no. 7, Aug. 12, 1926, pp. 244–247, 7 figs. Aluminum pistons with invar struts, redesigned combustion chambers, new clutch, novel spring construction and body changes made on both chassis.

Planetary. The Assembly of Planetary Gears, H. E. Merritt. Engineer, vol. 142, no. 3688, Sept. 17, 1926, p. 312. Discusses cases which at first sight do not appear to permit assembly, and presents simple rules which may be applied to every type of planetary gear; considers simple and compound planetary gears.

Stub Teeth. The Strength of Stub Teeth, W. E. Wright. Engineering, vol. 122, no. 3165, Sept. 10, 1926, pp. 316–317, 3 figs. Main features of stub tooth are that addendum and dedendum are smaller than those of Brown and Sharpe standard, while angle of contact is greater; discusses three principal systems of measurements of stub teeth in vogue, in all of which measurements along pitch circle are unaltered.

Teeth in Action. Gear Teeth in Action, E. Buckingham. Am. Mach., vol. 65, nos. 10 and 11, Sept. 2 and 9, 1926, pp. 389–392 and 451–454. Sept. 2: Eliminating gear noise in relation to uniformity of profiles and spacing; effect of eccentricity on gear noises; "Music of Gears;" resonance; harmonious ratios. Sept. 9: Relation of noise to design of gear blanks, cases and carriers; function of lubricant on gear teeth; selection of proper lubricant to meet various conditions.

Testing. The Testing of Gear Wheels. Metallurgist (Supp. to Engineer, vol. 142, no. 3689), Sept. 24, 1926, pp. 140–141, 2 figs. Refers to Lanchester's method of testing gears, and to new regenerative method, described by K. Kutzbach in Zeit. des Vereines deutscher Ingenieure (July 24, 1926, p. 999), which differs essentially in detail from Lanchester's method, and which appears to possess certain advantages; experiments were conducted with specially made gear wheels, all of 81-mm. pitch-circle diameter, 1 cm. in thickness and having 27 teeth.

Worm. Worm Gearing, H. E. Merritt. Machy. (Lond.), vol. 28, no. 724, Aug. 26, 1926, pp. 605–607, 4 figs. Theory and practice of design; detail dimensions of straight-sided worms; elements of worm-gear action; calculation of nominal and actual pitch diameters.

GOVERNORS

Steam-Turbine. Principles of Steam Turbine Governors. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 991–996, 14 figs. Construction details and method of operation of various makes of governors in present-day use.

GRINDING

Cylindrical. Cylindrical Grinding Without Traverse, J. Denton. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, p. 476, 1 fig. Describes grinding to diameter of outer races or cups, of roller bearings.

GRINDING MACHINES

Centerless. Heim Centerless Grinding Machine. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 63–64, 3 figs. Improved machine developed by Heim Grinder Co., Danbury, Conn.; important feature of which is hydraulic control; this control is used in spot or in-feed grinding, eliminates all waste time in movements of regulating-wheel slide. See also Am. Mach., vol. 65, no. 10, Sept. 2, 1926, pp. 421–422, 3 figs.

Gear-Tooth. Worm and Gear Tooth Grinders are New Pratt & Whitney Products. Automotive Industries, vol. 55, no. 7, Aug. 12, 1926, pp. 256–258, 7 figs. Former unit finishes either or both sides of thread at once; latter machine generates tooth involute by special mechanism.

GUN METAL

Porosity, Prevention of. Prevention of Porosity and Improvement in the Physical Properties of Gun-metal, W. Reitmeister. Foundry Trade Jl., vol. 34, no. 523, Aug. 26, 1926, pp. 177–180, 5 figs. Account of experiments, object of which was to find substitute for uniform type of gun metal containing 85 per cent copper; 9 per cent tin and 6 per cent zinc, hitherto used by German railways; other experiments were carried out to determine effect of position of tensile test bars within casting, and method of casting, whether oblique, vertical or horizontal, using dry and green sand molds. Paper presented before German Foundrymen's Assn. Translated from German.

H

HARDNESS

Testing. Methods of Hardness Testing. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, p. 501, 2 figs. Rockwell hardness testing. Reference-book sheet.

HEAT TRANSMISSION

Theory. The Theory of Heat Transmission (Ueberblick über die Lehre von der Wärmeübertragung), H. Gröber. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 34, Aug. 21, 1926, pp. 1125–1128, 3 figs. Significance of heat-transmission coefficient; empirical and mathematical-physical method of research; heat transmission in solid bodies and in pipes; radiation of surfaces of solid bodies; radiation of gases; relation of theory of heat transmission to important technical problems.

HEATING, HOUSE

Vancouver, B. C. House Heating in Vancouver B. C., J. Keillor. Am. Gas Jl., vol. 125, no. 10, Sept. 4, 1926, pp. 212–214 and 224. Efficiencies of hot-water, warm-air and Rector vacuum heating compared.

HEATING, STEAM

Central. The Barmen Central Heating Plant (Das Heizkraftwerk Barmen), K. Rheineck. Gesundheits-Ingenieur, vol. 49, no. 31, July 31, 1926, pp. 469–475, 18 figs. Discusses choice of system, central plant, pipe lines, canals, insulation, steam distribution in city for heating; utilization of waste steam from electric power plant; total capacity, 60,000–65,000 tons of steam per year.

Economic Construction of Central Heating Plants (Wirtschaftliche Fertigung für Zentralheizungsanlagen), J. Rössler. Gesundheits-Ingenieur, vol. 49, no. 30, July 24, 1926, pp. 454–459, 14 figs. Calculation of heat losses; preparing plans; details of construction, and equipment used; acceptance test, time study, etc.

Humid-Air Method. Analyzing the Humid Air Method of Steam Heating Buildings, T. N. Thomson. Plumbers Trade Jl., vol. 81, no. 4, Aug. 15, 1926, pp. 369–370 and 405. Mechanical construction of radiator steam valve and Venturi tube at radiator inlet, which are elements that made humid-air method possible.

Low-Pressure. Operating Data on Low Pressure Heating in Minneapolis Schools, A. L. Sanford. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 32, no. 9, Sept. 1926, pp. 647–654, 2 figs. Comparison of high- vs. low-pressure plants and description of typical heating plants of Minneapolis Public Schools. Paper read before Nat. Assn. Pub. Schools Officials, Toronto.

HYDRAULIC TURBINES

Developments. Recent Developments in Water Power Equipment. Power Engr., vol. 21, nos. 241, 242, 244, 245 and 246, Apr., May, July, Aug. and Sept. 1926, pp. 125–126, 174–176, 258–261, 301–303 and 344–346, 26 figs. General survey having special reference to large-powered units; essential features of modern machines. May: Gate mechanism of special design; double-wheel horizontal turbines; governing; turbines at Raanaasfoss, Sweden. July: High-speed reaction turbines; American turbines operating on 800-ft. head; large Pelton-wheel practice; governing. Aug.: Propeller-type water turbines. Sept.: Methods of control.

Pitting of Runners. Pitting of Hydraulic Turbine Runners. Nat. Elec. Light Assn.—Report, no. 256–318, Apr. 1926, 31 pp., 14 figs. Study for purpose of collecting actual experience data from operating companies in United States and Canada, and to classify and analyze these data in such fashion as to throw light on causes of and means of preventing pitting.

Propeller-Type. A 7500 Horse-Power Propeller Type Water Turbine. Engineer, vol. 142, no. 3686, Sept. 3, 1926, pp. 254–256, 6 figs. Turbines under construction for Kachlet Power Plant on Danube River by J. M. Voith, Germany; turbine is designed for total output of 7500 hp. when working under normal head of 7.65 m. and with water consumption of 87.5 cu. m. per sec., speed being 75 r.p.m.

Tests. Turbine Testing (Turbinprövning), H. Stub. Teknisk Ukeblad, vol. 73, no. 31, Aug. 6, 1926, pp. 271–275, 5 figs. Reviews development of turbine-testing methods; describes new testing station of Kvaerner Brug Co., and methods used; calculations.

25,000-Hp. A 25,000-H.P. Water Turbine and Alternator. English Elec. Jl., vol. 3, no. 5, July 1926, pp. 201–212, 16 figs. Details of "English Electric" turbine and generator installed in Sorocaba power station by Sao Paulo Elec. Co.; it is reaction type and operates under head of 670 ft.; alternator has full-load output of 20,500 kva., 3-phase, 60 cycles per sec., and power factor of 0.88 and pressure of 6600 volts when running at 600 r.p.m.

HYDRAULICS

Formulas. Do all Hydraulic Formulas Contain a Temperature Error? (Nog eens: Vertoonen alle hydralica formules eene temperatuurfout?), Proper. Waterstaats-Ingenieure, vol. 14, no. 4, Apr. 1926, pp. 102–112, 5 figs. Discusses fact that formulas intended for temperate zone require correction for tropical zone, and illustrates necessary correction in case of flow of water through pipes.

Problems. Some Problems in Hydraulics and River Engineering, E. S. Bellasis. Engineer, vol. 142, no. 3684, Aug. 20, 1926, pp. 202–203, 2 figs. Changes in rivers; dam sites; silt and scour; canals without barrage; backwater problems.

Symbols for Formulas. Standard Symbols for Formulas in Hydraulics (Einheitliche Formelzeichen in der Hydraulik). Zentralblatt der Bauverwaltung, vol. 46, no. 23, June 9, 1926, pp. 287–288. Communicated by Preussische Versuchsanstalt für Wasserbau u. Schiffbau at Berlin.

HYDROELECTRIC PLANTS

Inspection. Routine Inspection Procedure for Power-Station Equipment, C. R. Reid. Power, vol. 64, no. 13, Sept. 28, 1926, pp. 482–486, 6 figs. Although methods of inspection and record keeping described are for large hydroelectric stations, they can be used as basis for working up systematized inspection schedule for almost any size or type of plant.

Preparatory Work. Preparatory Hydraulic Work for Hydroelectric Plants (Notizen über hydraulische Vorarbeiten für Wasserkraftanlagen), H. Roth. Schweiz. Elektrotechnischer Verein—Bul., vol. 17, no. 6, June 1926, pp. 214–218. Importance of careful and extensive measurements of water supply and conditions for making reliable measurements prior to design of plant.

I

INDICATORS

High-Speed. The Gale High-Speed Indicator. Engineer, vol. 142, no. 3689, Sept. 24, 1926, pp. 332–333, 1 fig. Differs from R. A. E. instrument, not only by virtue of fact that its operation is wholly mechanical, but in important respect that pressures are recorded on normal basis of indicator diagram, namely, that of piston displacement, and not on crank angle or time basis, which requires subsequent reduction to piston-displacement basis.

INDUSTRIAL MANAGEMENT

Budgetary Control. Budgetary Procedure for the Rubber Industry. Mfg. Industries, vol. 12, no. 3, Sept. 1926, pp. 189–194. Report prepared to show how to overcome difficulties in installation and operation of budgetary-control system; entire procedure is broken down into schedules; factors for each are given in detail and tie-up is plainly indicated between schedules in making complete program.

Control Chart. Stock and Production Control Chart, H. Hill. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 15–16. Discusses control chart which gives following information: material on hand; material on order and order numbers; material received and graphic representation of material balance; guide to purchasing.

Forecasting, Probability Chart for. The Use and Limitations of the Arithmetic Probability Chart in Forecasting, A. P. Ackerman. Indus. Mgmt. (N. Y.), vol. 72, no. 3, Sept. 1926, pp. 165–167, 6 figs. Gives two examples serving to illustrate simple method of applying probability-chart paper to forecasting.

Manufacturing Control. Estimating Forthcoming Orders by the Pooled Orders Index, J. H. Barber. Mfg. Industries, vol. 12, no. 3, Sept. 1926, pp. 199–202, 4 figs. Shows ways in which confidential pooled-orders index, developed by Walworth Co., give definite guidance.

Manufacturing Losses, Reducing. Tracing that Average 28 Per Cent Loss, C. U. Carpenter. Mfg. Industries, vol. 12, no. 3, Sept. 1926, pp. 179–184, 4 figs. In plant having 8000 employees production increased and costs came down when author set standards for each job; established bonus system, and provided additional incentive through three-step plan of promotion.

Production Methods. Bringing Production Methods to the Job Shop, J. Younger. Am. Mach., vol. 65, no. 9, Aug. 26, 1926, pp. 349–351. One production shop, The Packard Motor Car Co., not only specifies chemical constituents of its steels, but also stipulates physical factors and further adds microphotographic specification; material turnover in job shop; standardization and simplification.

Purchasing Schedules. Complete Graphic Checks on Purchasing Schedules and Deliveries, H. D. Murphy. Mfg. Industries, vol. 12, no. 3, Sept. 1926, pp. 211–212, 2 figs. Presents chart which is laid out on basis of complete units being used for charting such items as are bought already fabricated and put immediately into finished stock; requirement schedule is laid out in its relation to operation of assembling; this system, to function properly, must be followed up unremittingly.

Tool and Stores Control. Establishing Tool and Stores Control, A. Merz. Mfg. Industries, vol. 12, no. 3, Sept. 1926, pp. 175–178, 5 figs. Improved methods in manufacturing and maintenance departments adopted by Heller & Merz, manufacturers of aniline colors, ultramarine, barrel paints, etc.; issuing of storeroom supplies; installation keeps down inventories and prevents shortage of supplies.

INDUSTRIAL RELATIONS

Future of. The Future Relationship Between Employer and Employed, R. A. Hadfield. Indus. Mgmt. (Lond.), vol. 13, no. 8, Aug. 1926, pp. 358–359. Messages received from leaders of industry on future relationship between employer and employee and its bearing on industrial reconstruction; outlines conciliation system by which industrial strife may be avoided; striking just balance between capital and labor.

INDUSTRIAL TRUCKS

Automobile Manufacturing Plants. How the Automotive Industries Have Put the Electric Industrial Truck to Work, H. J. Payne. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 88–95, 15 figs. Discusses practical application of industrial trucks, handling fender stock; use in forge plants and in malleable foundry, in body-building plant, and in glass plant; building automobile tires.

INSULATION, HEAT

Developments. Heat Insulation, R. H. Heilman. Engrs. & Eng., vol. 43, no. 8, Aug. 15, 1926, pp. 209–218, 5 figs. Author traces development of heat insulation during past 40 years; presents tables showing efficiencies, heat savings and unit heat losses which can be obtained from 3-in. thickness at heat insulation, and time required to repay original cost and

savings per year for temperatures of 500 to 600 deg. fahr.; explains how to make intelligent use of tables.

Houses. The Place of Building Insulation in the Conservation Program. Heat. & Vent. Mag., vol. 23, no. 9, Sept. 1926, pp. 69–74, 8 figs. One of most complete and convincing demonstrations of value of house insulation was furnished by home of H. S. Ashenhurst, Chicago; comparison of two Iowa houses; how insulation cut gas bills; heat-loss data for typical home; heat-loss constants for building materials uninsulated and insulated with insulex; cork as insulator; uses of insulating quilt.

Tests. Heat Insulator Tests, C. H. Herter. Refrig. World, vol. 61, no. 8, Aug. 1926, pp. 9–12, 1 fig. Deals with such insulating materials as lith, balsam wool, Cabot's eel-grass quilt, pyrocell, thermofill, house lining, and paper-pulp boards.

INTERNAL-COMBUSTION ENGINES

Compression-Ignition. Improving the Performance of a Compression Ignition Engine by Directing Flow of the Inlet Air, C. Kemper. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 242, July 1926, 9 pp., 6 figs. Results of tests to determine effect on engine performance of directing flow of inlet air to 5-in. by 7-in. single-cylinder, soild-injection, compression-ignition engine; it was found that directing flow of inlet air towards fuel-injection valve gave steadier engine operation, appreciable increase in power and decreased fuel consumption; results indicate simple means for improving air flow in given combustion chamber without changing its shape.

Dust-Driven. An Engine that Runs on Dust, W. A. Noel and R. Hellback. Power, vol. 64, no. 11, Sept. 14, 1926, pp. 402–404, 5 figs. That engines can run on such dust as elevator floor sweeping, starch dust and powdered coal, has been proved in tests by Bureau of Chemistry, Department of Agriculture; preliminary experiments suggest that more attention be given to solid-fuel engine.

Fuel-Air Mixture. Determination of Size of Fuel Drops in Mixture Fog of Internal-Combustion Engines (Grössenbestimmung der Brennstofftropfen im Gemischenebel von Verbrennungskraftmaschinen), J. Sauter. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 31, July 31, 1926, pp. 1040–1042, 2 figs. Discusses phenomena occurring with production of fuel fog (fuel-air mixtures); fineness of atomization; measurement of size of fuel particles; measuring method based on an electrical effect and on photometric principle; results of measurements.

Solid-Injection. The Coal Fuel Engine. Gas & Oil Power, vol. 21, no. 251, Aug. 5, 1926, pp. 239–240, 5 figs. Development of solid-fuel internal-combustion engine by A. Schnürle, a German inventor; combustion is effected in special chamber which is in connection with working cylinder but separated from it by porous filter screen plate, through which gases can pass, but not coke and coal dust; chamber contains finely pulverized fuel which is in glowing state.

Temperature Stresses. Temperature Stresses and Deflexions in the Fins and Barrels of an Air-Cooled Internal Combustion Engine Cylinder, A. M. Binnie. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. of Science, vol. 2, no. 8, Aug. 1926, pp. 449–462, 21 figs. Attempt is made to evolve method of calculation; for simple case considered it is shown that much weight can be saved by reducing thickness of fins towards their tips; that spacing of fins is of importance; and that to small extent temperature stresses in fins assist barrel to withstand internal pressure in cylinder.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES.]

IRON ALLOYS

Stainless Iron. Stainless Iron, N. L. Mochel. Am. Soc. Steel Treating—Trans., vol. 10, no. 3, Sept. 1926, pp. 353–392 and (discussion) 392–394, 38 figs. Characteristics of low-carbon chromium-iron alloys known commercially as stainless iron; data relative to physical properties of alloys of varying heat treatment; elastic limit and impact values; effect of varying chromium content and silicon, copper, and nickel, on physical properties, microstructure, resistance to corrosion and workability of alloys.

IRON CASTINGS

Boiler with Cast-in Tubes. The Production of an Acid Resisting Cast-Iron Boiler of a Frederking Apparatus with Cast-in Coil Pipe for the Chemical Industry (Die Herstellung eines säurebeständigen Gusskessels eines Frederking-Apparatus mit eingegossenen Rohrschlangen für die chemische Industrie), A. Freitag. Giesserei, vol. 13, no. 18, May 1, 1926, pp. 338–341, 7 figs. Production and casting of completed mold; calculation of burden.

Cleaning and Grinding. Cleaning and Grinding Castings, R. Micks. Can. Foundryman, vol. 17, no. 8, Aug. 1926, pp. 7–8. In majority of foundries, tumbling mill is principal method of cleaning castings; sand blast is another valuable cleaning agent, but much depends on quality of abrasive used; portable grinding wheels.

Cost of. What Individual Castings Cost, T. Smith. Iron Age, vol. 118, no. 12, Sept. 16, 1926, pp. 762–763. Methods adopted by British iron foundry in analyzing cost of metal and of molding; how overhead is included.

Furnace Scrap in. Bad Castings and Furnace Scrap, H. H. Hopkins. Foundry Trade Jl., vol. 34, no. 522, Aug. 19, 1926, p. 164. Discusses question as to whether use of pig iron, made partly with scrap, results in defective castings; author gives practical results and points out errors in reasoning.

Hardening. The Hardening of Cast-Iron Machine-Tool Slides by Means of Quenching Plates (Beiträge zur Frage der Härtung gusseiserner Gleitbahnen durch Abschreckguss), H. Becker. Giesserei, vol. 13, no. 5, Jan. 20, 1926, pp. 81–84, 8 figs. Method employed to make slides more durable; examples of its application.

Machine Tools. Method for Obtaining High-Grade Castings in Machine-Tool Building (Verfahren zur Erzielung hochwertiger Gussstücke im Werkzeugmaschinenbau), M. Bernardy. Giesserei-Zeitung, vol. 23, no. 17, Sept. 1, 1926, pp. 476–481, 17 figs. Describes method according to which heavy machine-tool castings can be produced at low cost of molding as well as of melting and casting.

Reducing Cost of. Consideration of Production Possibilities in the Design of Castings (Rücksichtnahme bei der Konstruktion von Gussstücken auf die Herstellungsmöglichkeiten), L. Scharlibbe. Giesserei-Zeitung, vol. 23, nos. 15 and 16, Aug. 1 and 15, 1926, pp. 407–410 and 449–451, 36 figs. In order to cheapen products designer must pay more attention to cheaper and safer production methods than heretofore; author cites numerous examples to show how this is possible, even with complicated castings; shows also how it is possible to lessen danger of failures through pipe and crack formation.

Shrinkage. Shrinkage Cracks in Steel and Iron Castings, G. A. Luers. Nat. Engr., vol. 30, no. 9, Sept. 1926, p. 406, 1 fig. Author claims that in nearly 50 per cent of cases, breakage is traced directly back to foundry.

Straightening Warped. Straightening Warped Iron Castings, W. J. May. Mech. World, vol. 80, no. 2069, Aug. 27, 1926, p. 165, 3 figs. By careful heat treatment warping in most cases can be corrected without overmuch trouble; small partly machined castings which are warped will often recover their straightness by mere application of heat for some hours.

IRON FOUNDING

Art Castings. The Production of Art Castings (Studien über Formtechnik—Eisenkunst Guss), Diepschlag. Giesserei, vol. 13, no. 4, Jan. 23, 1926, pp. 61–64, 7 figs. Detailed description of molding of an iron art casting, (the figure of a man one-half life size) in experimental foundry of the Technische Hochschule in Breslau.

J

JIGS

Etching Symbols. Etching Symbols on Jigs and Fixtures, R. B. White. Am. Mach., vol. 65, no. 9, Aug. 26, 1926, pp. 367–368, 1 fig. The pantograph and matrices; composition of acid resisting ground; wax dam prevents acid from spreading; acids for etching different metals.

Manufacture. Production Pointers in Jig Making, C. C. Hermann. Can. Machy., vol. 36, no. 10, Sept. 2, 1926, pp. 17–19, 11 figs. Points out that making of bushing is difficult piece of work in ordinary shop, initial requirement being concentric hole so that surrounding metal will be uniform thickness.

L

LABOR

Bibliographies. Book Notes. Int. Labour Rev., vol. 14, no. 1, July 1926, pp. 135–150. International, official and non-official publications.

Publications Relating to Labor. Monthly Labor Rev., vol. 23, no. 2, Aug. 1926, pp. 236–239. Official and non-official publications in United States and foreign countries.

LATHES

Centers. Design of Lathe Centres, F. Horner. Machy. (Lond.), vol. 28, nos. 721 and 722, Aug. 5 and 12, 1926, pp. 528–532 and 564–568, 16 figs. Typical designs for different classes of work.

Engine. Heavy Gap-Bed Engine Lathe. Engineer, vol. 142, no. 3682, Aug. 6, 1926, pp. 148–149, 6 figs. Details of $8^1/_2$-in centers motor-driven lathe, made by Smith, Barker, and Willson, Halifax.

LOCOMOTIVE BOILERS

Pitting. Pitting of Locomotive Boilers, W. A. Pownall. Ry. Rev., vol. 79, no. 8, Aug. 21, 1926, pp. 263–270, 5 figs. Observations of boiler corrosion in various forms.

Water-Tube. Suggestions for a Watertube Locomotive Boiler, L. A. Rehfuss. Boiler Maker, vol. 26, no. 8, Aug. 1926, pp. 218–219, 2 figs. Outline of advantages to be expected from carefully developed water-tube locomotive-boiler design.

LOCOMOTIVES

Design and Construction. Locomotive Design and Construction. Ry. Rev., vol. 79, no. 6, Aug. 7, 1926, pp. 197–207, 29 figs. Abstract of progress report on building engines to reduce track stresses.

Diesel Engined. Geared Diesel Locomotive 2-E-1 of Russian State Railways (Diesel-Getriebelokomotive 2-E-1 für die Staatsbahnen der U. S. S. R.), G. Lomonossoff. Organ für die Fortschritte des Eisenbahnwesens, vol. 81, no. 11, June 15, 1926, pp. 193–198, 13 figs. Design of Diesel locomotive of 1200 hp., with gear transmission by Hohenzollern, A. G., comparison with Diesel-electric locomotive; advantages of former. (Transl. from Russian.)

Driving Wheels. On the Action of a Locomotive Driving Wheel, F. W. Carter. Roy. Soc.—Proc., vol. A112, no. A780, Aug. 3, 1926, pp. 151–157, 1 fig. Author attempts to compute tractive force per unit creepage to rail.

Four-Cylinder Compound. French Four-Cylinder Compound 4-8-2 Type Locomotive, M. Chambon. Ry. Age, vol. 81, no. 7, Aug. 14, 1926, pp. 276–278, 3 figs. Develops 41,446-lb. tractive force, with 40,000-lb. axle loads; grate area large for European practice.

4-6-2. New 4-6-2 Locomotives, Queensland Government Railways. Ry. Gaz., vol. 45, no. 9, Aug. 27, 1926, p. 259, 1 fig. This design includes many special features, and provides powerful class of engine for use on 3-ft. 6-in.-gage lines with heavy grades.

Results of Tests on a Four Cylinder 4-6-2 Locomotive, Class 10, of the Belgian State, F. Legein. Int. Ry. Congress—Bul., vol. 8, no. 8, Aug. 1926, pp. 663–672, 4 figs. Test results show that influence of superheat has had principal effect in fuel economy which has been realized. Translated from French.

High-Pressure. High-Pressure Three-Cylinder Compound Express Locomotive. Engineering, vol. 122, no. 3161, Aug. 13, 1926, pp. 198–200, 4 figs. Locomotives, designed and built by Henschel & Sohn, Cassel, Germany, for experimental purposes, in which attempt to employ high-pressure steam as evaporating agent is made; locomotive has three boilers, all steaming at different pressures; each is structurally distinct from the others.

Lubrication. A High-Pressure Locomotive Lubricator. Engineer, vol. 142, no. 3683, Aug. 13, 1926, p. 180, 5 figs. New type of forced-feed lubricator manufactured by Bosch Co.

Lubrication of Rod Bearings and Cross Heads of Locomotives (Die Schmierung der Stangenlager und Kreuzköpfe von Lokomotiven), W. Friedrich. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 31, July 31, 1926, pp. 1043–1044, 3 figs. Design and operation of new lubricator, working as pump, for reciprocating parts.

Oil-Engined. Transmission of Power on Oil-Engine Locomotives, A. I Lipetz. Mech. Eng., vol. 48, nos. 8 and 9, Aug. and Sept. 1926, pp. 797–806 and 929–940, 31 figs. Classification of power transmission in chronological order of their appearance in art; class A comprises full-power elastic-fluid transmissions; class B consists of differential elastic-fluid transmissions; class C pertains to mechanical (gear-clutch) and direct transmissions.

Pacific-Type. Atlantic & West Point Passenger Locomotives. Ry. Rev., vol. 79, no. 10, Sept. 4, 1926, pp. 331–333, 3 figs. Pacific-type engines designed to handle heavy trains over mountain grades at high speeds.

Steam-Turbine. The Ljungstrom Turbine Locomotive. Ry. & Locomotive Eng., vol. 39, no. 8, Aug. 1926, pp. 213–215, 2 figs. Condensing turbine with direct drive through reduction gears; shows efficiency and reliability in service.

Superheater. Locomotives for Firing of Brazilian Coal (Dampflokomotiven zur Verfeuerung brasilianischer Nationalkohle). Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 32, Aug. 7, 1926, p. 41 (advertising section), 2 figs. 1-D-1 twin-cylinder superheater locomotives for 1-m. gage, and for 1.6-m. gage, for burning of low-grade coal; built by German General Electric Co. (AEG).

New 2-6-0 Type Mixed-Traffic Superheater Locomotive, London, Midland & Scottish Railway. Ry. Gaz., vol. 45, no. 6, Aug. 6, 1926, pp. 170–171, 2 figs. Class intended for handling fast freight and heavy excursion trains.

Switching. Heavy Switching Locomotives for Wabash Railway, W. A. Pownall. Ry. Rev., vol. 79, no. 9, Aug. 28, 1926, pp. 295–298, 3 figs. Eight-wheel engine designed especially for transfer service and general yard work; built by Lima Locomotive Works.

Three-Cylinder. Three-Cylinder Mountain Type Locomotive. Ry. Age, vol. 81, no. 10, Sept. 4, 1926, pp. 431–433, 3 figs. Built for Denver & Rio Grande Western for heavy passenger service; tractive force, 75,000 lb.

LUBRICATING OILS

Viscosity. Viscosity and the Conradson Carbon-Residues of Lubricating Oils, G. W. Burke. Soc. Automotive Engrs.—Jl., vol. 19, no. 3, Sept. 1926, pp. 249–251, 4 figs. Deals with relationship between viscosity and Conradson carbon residues of lubricating oils for internal-combustion engines; presents evidence indicating that true relationship does not exist between viscosity at any temperature and carbon-residue value, and shows in general way what can be expected as to carbon-residue value when viscosity is known.

LUBRICATION

Protection. Lubrication Protection. Lubrication, vol. 12, no. 8, Aug. 1926, pp. 85–96, 22 figs. Oil filtration and purification; types of systems, namely, precipitation and filtration, centrifugal separation and mechanical coagulation of impurities with suitable chemicals; filtering and cleaning of air.

M

MACHINE DESIGN

Preliminary Models. Preliminary Models Reduce Machine-Design Costs, F. L. Eidmann. Am. Mach., vol. 65, no. 13, Sept. 23, 1926, pp. 511–514, 18 figs. Intricate shapes difficult to visualize from drawings alone; models may be full size or to reduced scale; examples of models and machines.

MACHINE TOOLS

Diagrammatic Cards for. Machine Tools and

Economic Management (Werkzeugmaschine und wirtschaftliche Betriebsführung), F. Theimer. Sparwirtschaft, vol. 3, nos. 7 and 8, July and Aug. 1926, pp. B136–B143 and B157–B164, 18 figs. Aspects for economic utilization of metal-cutting machine tools in the metal industry; drives for rotary and rectilinear motion, design and use of machine cards, and examples of such cards.

Operation. Fitting the Machine-Tool to the Job, O. C. Kavle. Soc. Automotive Engrs.—Jl., vol. 19, no. 4, Oct. 1926, pp. 399–408, 22 figs. Example is given of machine for boring and bottoming air-cooled engine cylinders that equals production of four machines of equal size which it has displaced; saving of handling time is exemplified in various other machine tools and is emphasized because if handling of material can be timed with machining operations, it may mean that cutting speed can be slowed down, thereby effecting saving of tool wear, or handling can be speeded up to keep pace with cutting speed.

Railway Shops. New Machine Tools for Railway Workshops. Ry. Engr., vol. 47, no. 560, Sept. 1926, pp. 308–311, 4 figs. Heavy motor-driven wheel lathe, and special machine, also motor-driven for boring axle-boxes.

Replacement Policy. Systematic Replacement of Machine Tools, H. K. Spencer. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, p. 19. Outlines method for systematically replacing machine-tool equipment in plant so that it may be kept up-to-date.

MACHINING METHODS

Locomotive Repairs. Machining Methods that Cut Locomotive Repair Costs, F. W. Curtis. Am. Mach., vol. 65, nos. 4, 5 and 6, July 22, 29 and Aug. 5, pp. 159–161, 193–194 and 249–251, 24 figs. Methods used in locomotive repair shop. July 29: Milling shoes and wedges, planing crossheads; reboring cylinders; boring and facing driving boxes; air-operated tools for squaring valve parts and cutting out superheater flues. Aug. 5: Turning in drill press; trepanning flue sheets; gages made in punch press.

MALLEABLE IRON

Black-Heart. Carbon in Black-Heart Malleable, C. Kluijtmans. Foundry Trade Jl., vol. 34, no. 521, Aug. 12, 1926, pp. 133–135, 9 figs. For black-heart malleable, carbon content must be between 2.20 and 2.60 per cent; under 2.20 difficulties will be encountered in foundry on account of poor fluidity of such iron and chance of shrink; over 2.60 per cent, although this iron is quite suitable for molding, higher carbon would produce primary graphite, thus precluding satisfactory annealing and in any case yielding weak casting; results of tests show that for similar annealing conditions the larger the initial masses of cementite the larger the resultant graphite.

Metallographic Tests. Investigations of Malleable-Iron Test Bars of Different Shape (Untersuchungen an verschieden geformten Zerreisstäben aus schmiedbarem Guss), H. Pinsl. Giesserei, vol. 13, no. 20, May 15, 1926, pp. 365–372, 35 figs. Results of metallographic investigations.

MATERIALS HANDLING

Automobile Manufacturing Plants. Ford Handling Practice at Highland Park, J. B. Webb. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 102–110, 25 figs. How moving-production principle has been applied to contributory products.

Chain Blocks. The Chain Block and its Almost Unlimited Field, F. C. Eibell. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 96–101, 14 figs. Discusses various types and their most economical applications; there are three general types in use; differential, screw-geared and spur-geared blocks.

General Electric Co., Schenectady. Where Size and Variety Complicate the Handling of Materials, R. H. Rogers. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 125–131, 15 figs. How General Elec. Co. solves its materials-handling problems.

Industrial Plants. Getting Production in a Limited Space, C. O. Herb. Machy. (N. Y.), vol. 33, no. 1, Sept. 1926, pp. 38–40, 10 figs. How lack of space was successfully overcome in one plant by adoption of time- and labor-saving methods of handling work.

Man Power. Lifting and Handling by Man-Power, F. L. Eidmann. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 111–114, 14 figs. Lift truck and portable elevator as reducers of handling costs.

Pneumatic Conveying. Up-to-Date Progress in the Pneumatic Handling of Dry Materials, E. J. Tournier. Indus. Mgmt. (N. Y.), vol. 72, no. 2, Aug. 1926, pp. 132–140, 14 figs. Latest designs of high-pressure pneumatic systems for handling dry materials are made in four principal forms, depending on dust content, local regulations and value of dust; typical applications of pneumatic conveying of bulk materials.

METALS

Corrosion. Principles and Methods of Testing the Submerged Corrosion of Metals, F. N. Speller, R. P. Russell and W. G. Whitman. Mass. Inst. of Technology—Publications, vol. 62, no 34, Aug. 1926, 8 pp., 6 figs. General principles and specifications for testing; submerged corrosion tests; method of reporting corrosion results and recommended testing methods.

Failure. Some Recent Researches and their Bearing on the Theory of Failure of Metals, H. J. Gough. Metallurgist (Supp. to Engineer, vol. 142, no. 3689), Sept. 24, 1926, pp. 132–133. Reviews researches made in last one or two years on nature of slip and examines to what extent various conclusions reached are in agreement; effects of slip on atomic structure, and nature of hardening under slip; author believes that results of recent researches have led to somewhat deeper insight into causes of failure of metals than was formerly possible.

Tensile Tests. The Testing and Properties of Materials (Werkstoffprüfung und Werkstoffeigenschaften), G. Sachs. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 35, Aug. 28, 1926, pp. 1167–1169. Analysis and review of tensile tests; author suggests that it will never be practically possible to isolate and to test separately various fundamental physical properties involved in idea of strength, even when this idea can be completely analyzed; meaning of results of test depends entirely upon nature of material; suggests that value of reduction of area at fracture as indication of plastic qualities of metal is not adequately appreciated; discusses question of arriving at something like a "figure of merit" in which results of tensile test might be summarized in single numerical value. See translated abstract in Metallurgist (Supp. to Engineer, vol. 142, no. 3689), Sept. 24, 1926, pp. 138–139.

Testing. Modern Testing of Materials and Its Application (Die neuzeitliche Materialprüfung und ihre kritische Auswertung), R. Hinzmann. Gewerbefleiss, vol. 105, no. 6, June 1926, pp. 117–124, 17 figs. Discusses methods of physical and mechanical testing; tensile strength and elongation, hardness, notched-bar strength; metallographic testing; lays stress on testing for behavior under given conditions.

MILLING MACHINES

Turbine Blades, for. Profile Milling Turbine Blades. Machy. (Lond.), vol. 28, no. 722, Aug. 12, 1926, pp. 558–559, 4 figs. By means of slight modifications to their well-known profiling and cam-milling machine, Webster & Bennett, Coventry, have been successful in adpating it for profile milling back of turbine blades.

MOLDING MACHINES

Flaskless. Progress in Design of German Molding Machines (Fortschritte im deutschen Formmaschinenbau), U. Lohse. Giesserei, vol. 13, no. 1, Jan. 2, 1926, pp. 1–6, 21 figs. Advantages and uses of flaskless molds; Barborossa hand-press molding machine; manipulation and efficiency; examples of pattern plates for such machines and of unusual castings made in sand molds.

Hand. Performance Tests with Three Different Hand-Press Molding Machines of the Same Flask Size (Leistungsversuche mit drei verschiedenen Handpress-Formmaschinen gleicher Kastengrösse), K. Köhler. Giesserei, vol. 13, no. 22, May 29, 1926, pp. 397–398. Based on comparative tests on three different high-grade machines, their efficiency and economy in operation are determined.

MOLDING METHODS

Large-Size Strainer. Method of Moulding a Large Size Strainer, J. H. List. Metal Industry (Lond.), vol. 29, no. 7, Aug. 13, 1926, p. 155. Method employed in molding strainer 6 ft. long overall with 36-in. outside diameter of body and 20-in. inlet bore.

Locomotive Cylinder. Molding of a Locomotive Cylinder (Einformen eines Lokomotivzylinders), K. Pierson. Giesserei, vol. 13, no. 15, Apr. 10, 1926, pp. 287–290, 2 figs. Production of a locomotive cylinder from cores made in dry sand.

Machine Molding. Machine Molding with Single Flask. Iron Age, vol. 118, no. 10, Sept. 2, 1926, pp. 604–606, 4 figs. Time for making ashpit molds lowered by machine combining jolt ram, rollover power draw, and other operations.

Upright Hand Molding. Time Studies for the Molding of a Plate Clutch (Zeitstudie für das Formen einer Scheibenkupplung), Tillmann. Giesserei, vol. 13, no. 32, Aug. 7, 1926, pp. 562–563, 2 figs. Points out that further saving in time can be effected by use of upright molding device.

Winding Drums. Methods of Molding Heavy Winding Drums (Formmethoden für schwere Seilscheiben), O. Schmidt. Giesserei, vol. 13, no. 17, Apr. 24, 1926, pp. 322–324, 9 figs. Describes in detail production of a heavy rope pulley by templet molding and with heavy cores.

MOLDS

Drying. The Drying of Molds, with Special Regard of Permissible Maximum Temperature (Ueber die Trocknung von Gussformen, unter besonderer Berücksichtigung der zulässigen Höchsttemperateur), W. Schultze. Giesserei, vol. 13, no. 35, Aug. 28, 1926, pp. 634–647, 15 figs. Based on tests, desiderata are determined for constructive development of driers with regard to high initial temperature, a high degree of saturation of exhaust air and other important factors.

Heat Economy of Mold-Drying Equipment in Foundries (Die Wärmewirtschaft der Form-Trockenvorrichtungen in den Giessereien), E. Sommer. Giesserei, vol. 13, no. 35, Aug. 28, 1926, pp. 628–634, 4 figs. Presents heat balances for driers and investigates what factors are necessary for judging heat economy of a drier.

Heat Economy of Mold-Drying Equipment in Foundries (Die Wärmewirtschaft der Form-Trocken-Vorrichtungen in den Giessereien), Wagner and Koch. Giesserei, vol. 13, no. 35, Aug. 28, 1926, pp. 609–628, 27 figs. Investigation of process of drying molds in drying ovens and other drying equipment, based on which thermotechnical rules are given for design and operation of such equipment. Bibliography.

Ingot. Life of Ingot Molds (Sur la Durée des Lingotières), A. Legrand. Fonderie Moderne, vol. 20, Aug. 1926, pp. 181–188, 4 figs. Discusses current formulas and ideas; excellent results obtained with theoretically poor composition and disastrous results with chemically perfect composition, etc.

MOTOR-BUS TRANSPORTATION

Working Costs. Omnibus Working Costs. Motor Transport, vol. 43, no. 1118, Aug. 16, 1926, pp. 222–223, 3 figs. Financial details and work records of Coventry Corp. passenger services for 1925–26.

MOTOR BUSES

Brakes. Bus Brakes, K. W. Stillman. Automotive Industries, vol. 55, no. 9, Aug. 26, 1926, pp. 334–335. Problems of design and maintenance.

Heating. Heating System to Battle Winter Winds, H. L. Debbink. Bus Transportation, vol. 5, no. 9, Sept. 1926, pp. 474–477, 7 figs. Northern service indicates need for at least 25 square feet of interior radiation for each cubic foot of body volume; system designed for Sedan-type bus; practical experience with steam heating.

MOTOR TRUCKS

Couplings. Couplings for Motor Trucks which are Proof against Accident (Unfallsichere Kupplungen für Lastkraftwagen), Castner. Dinglers Polytechnisches Jl., vol. 107, no. 13, July 1926, pp. 141–144, 12 figs. Couplings for trailers made by Krupp, Heinrich, Ahlborn and Scharfenberg, which were awarded prizes in competition arranged by Central Office for Accident Prevention of Germany for design which would prevent accident in coupling.

N

NON-FERROUS METALS

Melting. Melting Soft Metals, E. L. Gates. Gas Age-Rec., vol. 58, no. 8, Aug. 21, 1926, pp. 241–244 and 248, 5 figs. Gives table listing more commonly used commercial alloys; brass-melting furnaces using gas for fuel are of two types, crucible and non-crucible variety; recuperation and regeneration; cost of gas vs. coal in melting furnaces.

O

OIL

Preheaters. Oil Preheater Design, F. L. Kallam. Oil Bul., vol. 12, no. 8, Aug. 1926, pp. 847–848, 1 fig. Selection of metal for heater tubes; diameter and spacing of tubes; expansion of tubes and shells; oil and steam distribution.

OIL ENGINES

Airless-Injection. New Types on the Engine Market. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 551–552, 3 figs. In response to increasingly active demand for airless-injection engine of small and moderate power, Bessemer Gas Engine Co. is marketing single and twin-cylinder units of 40-hp. cylinder size; overhead camshaft and en bloc framing features of new design.

Austria, Hungary and Italy. Oil-Engine Construction in Austria, Hungary and Italy (Oelmotorenbau in Oesterreich, Ungarn und Italien), O. Klüsener. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 33, Aug. 14, 1926, pp. 1103–1108, 20 figs. Based on descriptions of noteworthy features of design and construction in several works visited by author, he outlines status of oil-engine construction in summer of 1925.

Combustion. Oil Engine Combustion Systems, C. E. Klitgaard. Pac. Mar. Rev., vol. 23, no. 8, Aug. 1926, pp. 358–360. Considers four phases of combustion, namely, injection, gasification, ignition, and actual combustion.

Combustion Control. Control of Combustion in Oil Engines, A. B. Newell. Nat. Engr., vol. 30, no. 9, Sept. 1926, pp. 419–421. Principles of operation and hints on operation, repair, maintenance, and adjustment of fuel-injection devices and valves of modern oil engines.

Convertible Oil-Gas Engines. Convertible Oil-Gas Engine. Mech. World, vol. 80, no. 2070, Sept. 3, 1926, pp. 179–180, 1 fig. Engines placed on market by National Gas Engine Co., Manchester, Eng., as suitable for use with either gaseous or liquid fuel; can be changed over quite simply from one to other as economic conditions dictate.

Fuel Combustion, Improvement of. Improving Fuel Combustion in Oil Engines, E. J. Kates. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 545–546. Increasing cyclic efficiency considered as possibility for reducing weight and cost.

Indicating. Indicating a Paraffin Engine, N. Harwood. Mech. World, vol. 80, no. 2067, Aug. 13, 1926, pp. 126–127, 5 figs. Indicating device employed and method of application.

Marine. Marine Oil Engine Trials. Instn. Mech. Engrs.—Proc., no. 3, Mar. 1926, pp. 523–595 and (discussion) 596–618, 32 figs.; also abstract in Engineering, vol. 121, nos. 3150, 3151 and 3153, May 28, June 4 and 18, 1926, pp. 639–641, 675–677 and 742–744, 26 figs. Results of tests of M. V. British Aviator and also engines, covering shore and sea tests. Vessel was propelled by Balmer-Camellaird-Fullagar, opposed-piston, 2-stroke cycle, single-acting oil engine with blast-air fuel injection.

Pistons. See PISTONS.

Sketches and Working. Sketches and Working of Oil Engines. Motorship, vol. 11, no. 9, Sept. 1926, pp. 686–690 and 695–696, 13 figs. Practical considerations underlying injection of fuel without use of compressed air.

Strain Meters for. Direct-Reading Strain Meter, J. Geiger. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 564–567, 10 figs. New instrument for measuring strains in engine parts by 200,000-fold magnification.

OIL FUEL

Combustion. The Combustion of Fuel Oil, W.

Kemp, Jr. Oil Eng. & Technology, vol. 7, no. 123, July 1926, pp. 303–308, 5 figs. Study of conditions for burning fuel oil efficiently.

Experiences with the Combustion of Fuel Oil in Power Plant Boilers, J. F. Barkley. Engrs. & Eng., vol. 43, no. 8, Aug. 15, 1926, pp. 221–224, 1 fig. Types of burners used are grouped into two general classes, those using steam to effect atomizing of oil, and those using mechanical means.

Gretna Burning System. Liquid Fuel Appliances. Machy. Market, no. 1347, Aug. 27, 1926, pp. 25–26, 7 figs. Distinctive feature of Gretna liquid-fuel system is found in burner, which can be operated by either steam or compressed air, as desired; another feature of system is swivel arrangement.

ORDNANCE

Rock Island Arsenal. Mobilization Planning at Rock Island Arsenal, Col. D. M. King. Am. Mach., vol. 65, no. 11, Sept. 9, 1926, pp. 433–436, 3 figs. In event of another national emergency, task has been assigned to Rock Island Arsenal of manufacturing, reconditioning, and shipping large quantities of ordnance material required to supply armies in field.

OXYACETYLENE CUTTING

Railway-Car Construction. Jet-Cutting Machines. Machy. (Lond.), vol. 28, no. 722, Aug. 12, 1926, pp. 541–544, 6 figs. Theory of oxygen cutting; preheating agents and cutting speeds; universal templet and universal mechanical machines; Hancock oxygen-cutting machine.

See also CUTTING METALS.

OXYACETYLENE WELDING

Roof Trusses. Tests on Oxwelded Roof Trusses, H. H. Moss. Welding Engr., vol. 11, no. 8, Aug. 1926, pp. 32–33, 5 figs. Demonstrating application of engineering principles and procedure control to oxyacetylene welding of structural steel.

Sheet Metal. Oxy-Acetylene Welding and Cutting, F. X. Morio. Sheet Metal Worker, vol. 17, no. 15, Aug. 27, 1926, pp. 573–574 and 580, 4 figs. Theory and practice as applied to sheet-metal trade with suggestions as to welding and cutting various metals.

Steel. Welding High Carbon Tool Steel and High Speed Steel with the Oxy-Acetylene Torch, G. L. Walker. West. Machy. World, vol. 17, no. 8, Aug. 1926, pp. 350–353, 3 figs. Author points out that there yet remains need for further study and development in methods and materials before these steels are as successfully and as extensively welded as are lower-carbon steels.

Textile-Mill Equipment. Oxy-Acetylene Welding Equipment for Mills. Textile World, vol. 70, no. 6, Aug. 7, 1926, pp. 63–64, 1 fig. Apparatus composing typical welding and cutting outfit capable of effecting large savings in any textile plant; advice in regard to purchase of torches, welding rods, flux, regulators, and hose; cost of portable unit.

P

PAPER MANUFACTURE

Parchment Paper. Parchment Paper and its Manufacture, M. DeKeghel. Paper Trade Jl., vol. 83, no. 10, Sept. 2, 1926, pp. 57–62. Parchmentizing with zinc-chloride apparatus for parchmentizing; properties and uses of parchment paper; parchment-paper preparations; artificial parchment.

PATENTS

Co-Patentees. Co-Patentees, E. L. Francis. Automobile Engr., vol. 16, no. 218, Aug. 1926, pp. 313–314. Consideration of their relative rights.

PATTERNMAKING

Correct and Incorrect Procedure. Correct and Incorrect Methods in Patternmaking (Das "Falsch" und "Richtig" im Modellbau), R. Löwer. Praktischer Maschinen-Konstrukteur, vol. 59, no. 29–30, July 24, 1926, pp. 319–321, 18 figs. Examples are cited showing how mistakes can be avoided and savings in pattern costs effected.

Fitting Irregular Shapes. Fitting Irregular Pattern Shapes, J. McLachlan. Can. Foundryman, vol. 17, no. 8, Aug. 1926, pp. 14–15, 7 figs. Describes several methods of fitting branches, ribs, and bosses on irregular shapes which are not rule-of-thumb and yet will be found very accurate, without use of geometry.

Machines and Driving Belts. Patternshop Machines and Driving Belts. Metal Industry (Lond.), vol. 28, nos. 24 and 25, June 11 and 18, 1926, pp. 554–555, 578–579. June 11: Combination-type and sandpapering machines. June 18: Advantages of wooden pulleys; belt problems.

Organizing Shop Work. Organising Pattern-Shop Work, J. Edgar. Foundry Trade Jl., vol. 34, no. 522, Aug. 19, 1926, pp. 165–166. Making large work; marking off timber; loam-board patternmaking; drawing boards; small work.

PIPE

Connections. A Problem in Pipe Connection, W. T. McClenahan. Power, vol. 64, no. 8, Aug. 24, 1926, pp. 274–275, 2 figs. Presents results of mathematical analysis which develops fairly simple formulas applicable to any case.

PISTONS

Anti-Detonation. Anti-Detonation Piston (La possibilité de réaliser de hautes compression sans antidétonants), P. Dumanois. Génie Civil, vol. 88, no. 26, June 26, 1926, p. 570; also translated abstract in Automotive Abstracts, vol. 4, no. 8, Aug. 20, 1926, p. 242. Describes new piston and gives specific data on its design and results obtained; it was found possible to increase compression ratio of engine to 6.7 without any detonation whatever and with considerable improvement in economy on road; author claims that high compression can be made permissible simply by design without any anti-detonant whatever.

Oil Engines, for. Light-Metal Piston for Oil Engines. Oil Engine Power, vol. 4, no. 9, Sept. 1926, pp. 548–550, 4 figs. Type of aluminum-alloy piston recently found best adapted to Diesel engines was first proved out by extensive practical use; pistons are cast of special alloy of nickel, aluminum, and copper, produced by process which results in complete union of metals; bands of steel are cast in metal of skirt, one above piston pin, one near bottom edge, with additional bands in other locations if required.

PLANERS

Open-Side. Whipp Open-Side Planer-Shaper Improved, 26- and 36-in. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, pp. 505–506, 2 figs. Table is oscillated by means of usual slotted-crank mechanism employed for shapers; hence reversal of motion takes place within machine, and single-direction pulley or motor is used to drive.

POWER

Costs Investigation. The Investigation of Power Costs, W. A. Shoudy. Mfg. Industries, vol. 12, no. 3, Sept. 1926, pp. 203–206, 6 figs. Methods for studying utilization and generation of power to show where costs can be reduced.

POWER TRANSMISSION

Lineshaft Drive. Erecting and Aligning a Lineshaft Drive, G. Trimm. Indus. Engr., vol. 84, no. 9, Sept. 1926, pp. 398–401, 2 figs. Procedure in installing shaft which is of considerable length.

PRESSES

Blanking, for. Selecting Proper Size Press for Blanking, C. W. Lucas. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, pp. 280–283, 6 figs. Method of calculating proper-size press for blanking, punching, drawing, etc.; various types of power presses compared.

PRESSURE

Variation with Temperature. The Variation of Pressure with Temperature in Evacuated Vessels, N. R. Campbell. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. of Science, vol. 2, no. 8, Aug. 1926, pp. 369–383, 2 figs. Pressure-temperature coefficient in glass vessels; nature of gas evolved; consequences for high vacuum technique; characteristics of glasses used for vessels.

PROJECTILES

Tolerances. Sane Specifications and Intelligent Inspection, C. L. Ruggles. Mech. Eng., vol. 48, no. 9, Sept. 1926, pp. 909–915, 11 figs. Points out that problem of tolerances to be allowed in projectile manufacture can be solved only by experimental study of effects of dimensional variations.

PULVERIZED COAL

Boiler Firing. Pulverized-Coal Firing (Einige Bemerkungen über Kohlenstaubfeuerungen), W. Lulofs. Elektrotechnische Zeit., vol. 47, no. 24, June 17, 1926, pp. 694–696, 3 figs. Discusses necessity for intensive cooling of walls of combustion chamber in pulverized-coal furnaces; determination of cooling effect of combustion chamber, based on temperature measurements of flue gases, determination of CO_2 content and through introduction of term combustion characteristic for a given class of coal; this term is discussed in detail.

Pulverized Coal is Fuel for Industrial Plants (Poederkool als brandstof voor industrieele stookinrichtingen), D. Dresden. Ingenieur, vol. 41, no. 25, June 19, 1926, pp. 505–507, 2 figs. Advantages of pulverized coal firing and its application in various countries, including Holland.

Coal-Mine Power Plant. Pulverized Coal for Coal-Mine Stations (Die Kohlenstaubfeuerung auf der Schachtanlage Hilger und Hagedorn der Zeche Ewald), A. Röttger and M. Schimpf. Glückauf, vol. 62, no. 26, June 26, 1926, pp. 825–830, 7 figs. Describes plant at Ewald coal mine in Westphalia, characterized by use of central pulverizing plant; reasons for adoption of central plant in preference to unit pulverizers; layout and operation of plant; data from boiler trials.

Gasified-Fuel Burning System. The Gasified-Fuel System of Burning Pulverised Coal. Engineering, vol. 122, no. 3164, Sept. 3, 1926, pp. 294–296, 9 figs. System of burning pulverized fuel, invented by E. S. Suffern, object of which is to reduce combustion space required, and to render system applicable to existing boilers, including those of internally fired type, as well as to firing of kilns and furnaces for various industrial heating processes. See also Engineer, vol. 142, no. 3686, Sept. 3, 1926, pp. 256–257, 3 figs.

Sugar Mills. Producing Sugar with Pulverized Coal, A. Murphy. Power House, vol. 19, no. 15, Aug. 5, 1926, pp. 19–26 and 52, 15 figs. Describes new power plant of Dominion Sugar Co. at Wallaceburg, Ont., in which three 670-hp. water-tube boilers, fired with pulverized coal, are effecting saving of 50 tons of fuel a day.

PULLEYS

Types and Characteristics. Pulleys. Power Engr., vol. 21, no. 246, Sept. 1926, pp. 347–349, 3 figs. Notes on several types and their characteristics.

PUMPS

Boiler-Feed. Boiler-Feed Pump Characteristics. Mech. World, vol. 80, no. 2065, July 30, 1926, pp. 79–80, 2 figs. Summarizes argument contained in pamphlet entitled The All-Electric Boiler-Feed Pump, issued by Mather and Platt, Manchester, Eng.; considers relative economies of steam-driven and electrically driven pumps; typical characteristics of various types of pumps.

PUMPS, CENTRIFUGAL

Self-Priming. A Self-Priming Centrifugal Pump. Engineer, vol. 142, no. 3683, Aug. 13, 1926, p. 179, 1 fig. Details of small Elmo pump, supplied by Siemens-Schuckert, and exhibited in South Kensington Science Museum, which will even continue to operate when it is sucking a considerable proportion of air with water.

Specifications. Centrifugal Pump Specifications Should be Complete, C. C. Brown. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 996–997, 1 fig. Characteristics should be studied for each installation and all terms used in specifications defined.

R

RAW MATERIALS

America. The Economics of Monopolies of Raw Materials, with Particular Reference to America. Chem. & Industry, vol. 45, no. 31, July 30, 1926, pp. 247T–259T, 12 figs. Discusses policy of United States in control of raw materials.

REFRACTORIES

Carborundum. Carborundum as a Refractory Material, B. Kleinschmidt. Chem. Age, vol. 15, no. 373, Aug. 21, 1926, p. 178. Its increasing use in Germany; properties of carborundum and industrial applications.

Firebrick. See FIREBRICK.

Firebrick-Coal-Ash. Fusion Points of Firebrick-Coal Ash Mixtures, L. C. Hewitt. Am. Ceramic Soc.—Jl., vol. 9, no. 9, Sept. 1926, pp. 575–582, 4 figs. Six types of refractory brick were tested with five types of coal ash; cone fusion points of brick-ash mixtures being determined over range of 10 per cent brick, 90 per cent ash to 40 per cent brick, 60 per cent ash; results obtained indicate that cone-slag test is of very limited value as means of selecting refractories for boiler service.

Softening Test. Measuring Temperature in Softening Tests of Refractories under Pressure (Die Temperaturmessung beim Druckerweichungsversuch an feuerfesten Baustoffen), W. Miehr. Sprechsaal, vol. 59, no. 17, Apr. 29, 1926, pp. 261–264, 3 figs. Describes method of measuring accurately temperatures in softening tests of refractories under a load of 2 kg. per sq. cm. which is simple and convenient in its technical arrangement, and cheaper than other methods depending on optical pyrometer.

Measuring Temperature in Softening Tests of Refractories under Pressure (Temperaturmessung beim Druckerweichungsversuch), H. Hirsch. Tonindustrie-Zeitung, vol. 50, no. 44, June 9, 1926, pp. 793–794, 3 figs. Describes method adopted by chemical laboratory for clay products, agreement of results with those of Miehr, use of additional gaging.

Sources of Error in Determination of Softening Temperature of Refractories Under Load (Fehlerquellen bei der Bestimmung der Druckerweichungstemperatur feuerfester Baustoffe), O. Bartsch. Sprechsaal, vol. 59, no. 20, May 20, 1926, pp. 311–313, 3 figs. Discusses sources of error in measuring temperature, shrinkage, improper position of refractory in fire tube, etc., and proposes establishment of sets of standard refractories of control for each range of softening temperature in order to secure comparable results.

REFRIGERATING MACHINES

Absorption. A New Absorption Refrigerating Machine (Une Nouvelle machine frigorifique à absorption), R. Villers. Nature (Paris), no. 2730, July 31, 1926, pp. 75–77. Describes new Munten-Platers machine in which most of disadvantages of old absorption machines have been eliminated; it comprises neither pump nor expansion cock; works on continuous cycle.

High-Speed. Modern High Speed Refrigerating Machines, G. W. Daniels. Brit. Cold Storage & Ice Assn., vol. 22, no. 2, 1925–26, pp. 5–20 and (discussion) 21–45. Summarizes relative advantages of high-speed and low-speed types; points out that adoption of higher speeds necessitates number of changes in design, most important of which are discussed, such as valves, suction pipes and passages, lubrication, balancing, scantlings and motion work; types and examples of machines.

REFRIGERATION

Electric. A Record in Electric Refrigeration. Elec. World, vol. 88, no. 9, Aug. 28, 1926, pp. 424–425, 1 fig. Ohio Public Service Co. attains 2.3 per cent saturation of customers; experience in selling and installation; definite plan of sales organization.

REGULATORS

Accelerometer-Tachometer. The Charmilles Accelero-Tachometric Regulator (Le régulateur accélérotachymétrique des Ateliers des Charmilles S. A. à Genève), M. E. Volet. Technique de la Suisse Romande—Bul., vol. 25, no. 16, July 31, 1926, pp. 190–196, 19 figs. Describes operation of regulator for turbines, etc., consisting of an independent accelerometer and tachometer characterized by absence of dash pots and friction in main parts, accelerometer operating from the very start, whatever position of tachometer.

RESEARCH

Industrial. British Workshops Industrial Research. World Power, vol. 6, no. 33, Sept. 1926, pp.

159–164, 5 figs. Notes on Research Laboratories of (Brit.) General Electric Co.; main pipe trunks; electricity supply; routine testing, and laboratory-factory.

S

SAFES

Construction. Recent Progress in the Production of Safes (Récents progrès dans la fabrication des coffres-forts), J. Boyer. Nature (Paris), no. 2708, Feb. 27, 1926, pp. 135–142, 11 figs. Details of construction; frames, doors, etc.; safety vaults for banks; use of steels which is unbreakable and proof against drilling, oxyacetylene blowpipe, etc.

SAFETY

General Electric Co. Plants. Safety Activities at General Electric Company Plants, G. E. Sanford. Safety, vol. 12, no. 4, Sept.-Oct., 1926, pp. 101–110, 17 figs. Safety work is under direction of committee of sixteen, which meet as often as may be required; considerable amount of research is carried out under direction of committee; plant inspections at Schenectady are made by committee of workmen; each plant has its own safety organization.

SAND, MOLDING

Constitution. The Constitution of Molding Sand (Ueber die Konstitution der Formsande), E. Diepschlag. Giesserei, vol. 13, nos. 7, 8, 9, 10 and 11, Feb. 13, 20, 27, Mar. 6 and 13, 1926, pp. 125–130, 149–154, 173–176, 189–194 and 209–213, 26 diagrams, 20 figs. Methods of testing molding sand and results obtained; relations between grain size and gas permeability, and between grain size and strength; sedimentation of finest constituents; synthetic molding sands; recovery of used sands and improvement of unused sands; methods of sand dressing, economy and results.

Handling Systems. Sand Handling System Yields Economies, R. A. Fiske. Iron Age, vol. 118, no. 11, Sept. 9, 1926, pp. 703–705, 4 figs. Equipment for handling and distributing sand in steel foundry saves labor and floor space, speeds up production, and simplifies shop routine.

Testing. Testing of Molding Sand (Körnungs-Versuche an Formsanden), F. Roll. Giesserei, vol. 13, no. 6, Feb. 6, 1926, pp. 105–107, 7 figs. Tests to determine grain size and water permeability of molding sand.

SCREW MACHINES

Automatic. Smallpiece $1^1/_2$-in. Automatic Screw Machine. Mech. World, vol. 80, no. 2070, Sept. 3, 1926, p. 179, 1 fig. Developed by Armstrong, Whitworth & Co., Manchester, Eng., to meet requirements of motor and aircraft industries; it is guaranteed to produce accurately most complex parts made from heat-treated high-tensile steels.

SCREWS

Measurement. Correction for Elastic Compression in the Measurement of Screws with Small Cylinders, G. A. Tomlinson. Machy. (Lond.), vol. 28, no. 724, Aug. 26, 1926, pp. 616–618, 2 figs. Points out that in accurate measurements of small screw, correction should be applied on account of compression that ordinarily occurs; presents nomogram for computing compression correction in effective diameter measurement.

SHAFTS

Aligning. How to Align Long Shafts, A. B. Newell. Power, vol. 64, no. 12, Sept. 21, 1925, p. 448, 2 figs. Method of establishing a straight line used by large firm in mechanical field.

SHEARS

Cutting Bars and Sections. Cutting Sections and Bars (Zerteilen von Form- und Stabeisen), E. Kühme. Praktischer Maschinen-Konstrukteur, vol. 59, no. 5–6, Feb. 6, 1926, pp. 49–53, 8 figs. Characteristic types of shearing machines; compares shearing with sawing as regards cleanness of cut, speed, current consumption and economy.

SILICON STEEL

Properties. The Properties of Silicon Steel (Ueber die Eigenschaften hochsilicierten Stahls), E. H. Schulz. Zeit. für angewandte Chemie, vol. 39, no. 26, July 1, 1926, pp. 806–807. Cast silicon steel has higher elastic limit and greater elongation than ordinary cast steel of like tensile strength; known properties show silicon steel to be very valuable for structural steel.

SLIDE RULES

Circular. A New Circular Slide Rule. Engineer, vol. 142, no. 3684, Aug. 20, 1926, p. 206, 2 figs. Calculator in circular form developed by W. H. Fowler; advantages claimed for instrument are that it is more portable, gives extremely accurate results, is more easily and quickly operated, and is independent of climatic conditions.

SOLDERS

Hard and Soft. Technical Hard and Soft Solders (Die technischen Hart- und Weichlote), W. Claus. Giesserei-Zeitung, vol. 23, no. 17, Sept. 1, 1926, pp. 463–473, 12 figs. Contribution to knowledge of soldering process and to standardization of hard and soft solder; theory of soldering process; questionnaire set up by author for selection of soldering material; nomenclature in soldering practice; color of solder.

STANDARDS

Machine Parts. Standard Parts and Their Application in General Machine Shops (Das Normteil in seiner Anwendung bei der allgemeinen Maschinenfabrik), A. Meckel. Maschinenbau, vol. 5, no. 15, Aug. 5, 1926, pp. 692–695, 7 figs. Discusses establishment of an independent standards department, use of symbols and card index of standards, elimination of drafting work for standard parts and use of prints instead; management of models, tools, etc., for production of standard parts.

STEAM

Critical Velocity. Critical Velocity of Steam with Counter-Flowing Condensate, W. A. Pearl and E. B. Parker. State College of Wash.—Eng. Bul. no. 13, vol. 5, no. 9, Feb. 1923, 18 pp., 2 figs. By critical velocity is meant maximum flow of steam that can be maintained without hindering continuous return of condensate; account of research to study conditions existing in one-pipe system and to arrive at conclusions that will be useful in any designs requiring counter-flowing condensate.

High-Pressure. Direct Measurements of the Total Heat of Steam at Pressures up to 1000 lb. per Square Inch, H. L. Callendar and G. S. Callendar. World Power, vol. 6, nos. 32 and 33, Aug. and Sept. 1926, pp. 67–76 and 147–150, 3 figs. Results of experiments with new type of boiler. Sept.: Observations of total heat near saturation; limits of accuracy.

STEAM ACCUMULATORS

Ruths. Steam Accumulators, H. E. Witz. Elecn., vol. 97, no. 2514, Aug. 6, 1926, pp. 154–155, 5 figs. Notes on their theory, application, and development; Ruths principle in practice; use in traction stations. Abstract translated from Elektrotechnische Zeit.

STEAM ENGINES

Bleeder-Type. A Bleeder-Type Steam Engine. Power, vol. 64, no. 11, Sept. 14, 1926, pp. 396–397, 3 figs. Exhaust belts of 6-cylinder uniflow are provided with selective process valves.

A Pass-Out Steam Engine. Engineer, vol. 142, no. 3686, Sept. 3, 1926, pp. 257–258, 8 figs. partly on p. 250. Engine installed in paper mill by Belliss and Morcom, to drive all machinery and supply low-pressure steam necessary for drying cylinder; it is standard triple-expansion set, differing from normal practice only in provision of means for abstracting some of steam between intermediate and low-pressure cylinders for heating purposes in paper machines.

Defects. Defects of Steam Engines and Their Elimination (Mängel an Dampfmaschinen und deren Beseitigung), Brüser. Wärme- u. Kälte-Technik, vol. 28, no. 15, July 28, 1926, pp. 169–173, 27 figs. Discusses main defects, including knocking of piston rings, leakiness of piston, water in cylinder, faults in valve gear and its parts, etc.

Horizontal, Aligning. Simple Directions for Aligning a Horizontal Engine, Wm. Brehmer. Power, vol. 64, no. 9, Aug. 31, 1926, pp. 336–337, 3 figs. Although approximate alignment test can be made without removal of any of running parts, more accurate results can be obtained if shaft, connecting rod, crosshead, piston, stuffing box, and cylinder head are removed; indicates general method of alignment.

Small-Size. Resonance Steam Engine (Der Resonanzdampfmotor), K. Baetz. Praktischer Maschinen-Konstrukteur, vol. 59, no. 23–24, June 12, 1926, pp. 247–248, 4 figs. "Resondamotor" steam engine of $^1/_4$ to 60 hp., replacing electric motors for driving fans, pumps, stirring apparatus, boats, etc.; it is almost noiseless and requires no attention.

STEAM GENERATION

Super-Pressure. Super-Pressure Steam Generation, D. Brownlie. Inst. Mar. Engrs.—Trans., vol. 37, Aug. 1926, pp. 103–133 and (discussion) 133–142, 5 figs. Attempt is made to give concise outline of subject; by super-pressure steam is meant use of pressures far beyond present average practice, and generally above 1200 lb. per sq. in. gage, intended mainly for power generation by means of engines or turbines, and with employment of apparatus different in principle to any ordinary-type boiler at present in common use.

STEAM GENERATORS

Benson Super-Pressure. Steam at 3200-lbs. Pressure. Ry. Engr., vol. 47, no. 560, Sept. 1926, p. 326. "Benson" steam generator and its significance for locomotive work.

STEAM METERS

Oil Refineries. Steam Meters in Refineries (Der Dampfmesser im Raffineriebetriebe), E. Belani. Petroleum, vol. 22, no. 23, Aug. 10, 1926, pp. 853–857, 12 figs. Describes steam meter by Bopp & Reuther of Mannheim, based on the Venturi principle, for better control of steam consumption, etc.

STEAM PIPES

Design. Design and Construction of Modern Power Plant Piping Systems, G. A. Smith. Nat. Engr., vol. 30, no. 9, Sept. 1926, pp. 413–417. Points out that after sizes of main steam header, boiler inlets, and leads to various units have been decided upon, it is necessary that pipe of sufficient weight be specified to take care of pressure and strains caused by expansion and contraction, and quality of pipe must be such as to insure long life.

High Pressure and Temperature. Steam Pipes for Extra High Pressure and Temperature, J. A. Aiton. Engineer, vol. 142, no. 3588, Sept. 17, 1926, pp. 315–316. For purpose of this paper, author fixes extra high pressure and temperature of steam at 440 lb. pressure and superheated to 750 deg., as these may be considered to be limits of normal working at present. (Abstract.) Paper read before Inst. Mar. Engrs.

Welded. Welded Steam Mains. Power Engr., vol. 21, no. 246, Sept. 1926, pp. 337–338. Precautions necessary for welding steam-pipe-line sections; describes typical installation.

STEAM POWER PLANTS

Bank Building. Power Plant and Accessories of the New Brotherhood of Locomotive Engineers Bank Building, Cleveland, O., W. C. M. Clark. Universal Engr., vol. 44, no. 2, Aug. 1926, pp. 19–23, 5 figs. Details of mechanical equipment of modern skyscraper.

High-Pressure. A Sixty-Atmosphere Steam Plant. Engineer, vol. 142, no. 3684, Aug. 20, 1926, pp. 204–205, 3 figs. Account of tests carried out by E. Josse, Charlottenburg, Germany, of high-pressure engine and boiler plant built for working pressure of 60 atmospheres, which has now been in successful operation at A. Borsig's works in Tegel.

Industrial. Our Industrial Power Plants and Their Effect on Power Rates, E. Douglas. Nat. Engr., vol. 30, no. 9, Sept. 1926, pp. 397–400, 1 fig. Points out that outlook for future permanency of business in equipment line for isolated plant is far brighter than outlook for industrial power business for central stations.

Paper Mills. Paterson Parchment Paper Co.'s New Plant at Edgely (Pa.). Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 984–990, 10 figs. Among interesting features of plant for new paper mill are installation of Stirling boilers, chain-grate stokers, Holly loop system for handling condensate and bleeder turbines.

STEAM TRAPS

Thermometer to Check Operation. Recording Thermometer Used to Check Operations of Steam Traps, R. A. Taylor. Power, vol. 64, no. 8, Aug. 24, 1926, p. 286. Where traps discharge water at temperature below 212 deg., which is boiling point at atmospheric pressure, recording thermometer can be used to good advantage to check their operations.

STEAM TURBINES

Breakdowns. Breakdowns of Steam Turbines and Engines. Engineer, vol. 142, no. 3684, Aug. 20, 1926, p. 201. Review of reports for 1925 issued by British Engine Boiler and Electrical Insurance Co., discussing most noteworthy breakdowns which have come under notice of company's inspectors during year.

Brown-Boveri. New Methods in Steam-Turbine Design (Neue Wege im Dampfturbinenbau), M. Blänsdorf. Praktischer Maschinen-Konstrukteur, vol. 59, nos. 27–28 and 29–30, July 10 and 24, 1926, pp. 287–292 and 314–316, 15 figs. Development of steam turbines; impulse and reaction types; Brown-Boveri types; method of securing vanes; rodless oil-pressure control.

Changing Operating Conditions for. Design Steam Turbine for Change in Operating Conditions. Elec. World, vol. 88, no. 8, Aug. 21, 1926, p. 377. Turbine that can be used with relatively low steam pressure and temperature in present station, but that with slight changes can be used with steam of high pressure and temperature when station is modernized, is being obtained by Trinidad Elec. Transmission Railway & Gas Co. of Colorado.

De Laval. The Behaviour of Air in a De Laval Turbine, R. H. Grundy. Instn. Mech. Engrs.—Proc., no. 3, Mar. 1926, pp. 619–630, 6 figs. Principal experiments of large series made to examine behavior of compressed air at various temperatures and pressures in De Laval turbine; with particular reference to temperature drop realized, and brake horsepower developed.

Extraction. Utilisation of Extraction Steam. Mech. World, vol. 80, nos. 2067, 2068 and 2069, Aug. 13, 20, and 27, 1926, pp. 129–130, 149 and 164. Part 1, E. D. Dickinson: Shows increasing demand for turbines where steam is to be used in manufacturing process. Part 2, A. D. Somes: Discusses ways in which various types of steam turbines may be applied to economical production of power and process steam for industrial processes. Part 3, R. G. Standerwick. Methods of regulating flow of steam through turbines with particular reference to extraction and mixed-pressure applications; applies to General Elec. Co. 3600-r.p.m. units.

Modern Design. Modern Steam Turbines (Die neuzeitliche Dampfturbine), E. A. Kraft. Elektrotechnik u. Maschinenbau, vol. 44, no. 21, May 23, 1926, pp. 396–398, 3 figs. Author considers 35 atmos. and 400 deg. cent. the generally accepted pressures and temperatures; it has recently been found that steam velocity in guiding portions of turbines should be low, and losses are least at 100 m. per sec.; this has led to increasing number of stages; four 50,000-kw. machines, having one casing only, have been installed at Rhenish Westphalian Electricity Works by German Gen. Elec. Co. (A.E.G.); others are being installed by same company at Rummelsburg station of Berlin, of 100,000 kva. each, running at 1500 r.p.m.

Packing Glands. Packing Glands for Large Steam Turbine Shafts. Power Plant Eng., vol. 30, no. 17, Sept. 1, 1926, pp. 947–950, 6 figs. Carbon ring, water seal, and labyrinth glands, or combinations of them, together with gland heaters form important item in successful operation.

Pressure Distribution. The Distribution of Pressure in Impulse Steam Turbines at Varying Loads, W. J. Kearton. Engineering, vol. 122, no. 3166, Sept. 17, 1926, pp. 365–369, 8 figs. Method whereby pressure and heat-drop distribution may be approximately predicted for operating conditions differing from designed conditions, and application of method to examples of practical interest and importance. Paper read before Section G of Brit. Assn.

STEEL

Alloy. See ALLOY STEEL.

Ball-Bearing. Ball-Bearing Steel (Ueber Kugellagerstahl), E. Houdremont and H. Kallen. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 31, July 31,

1926, pp. 1035–1039, 15 figs. Production and refining of ball-bearing steel; its structure and possible defects.

High-Pressure Steam. Sound Metal Needed for High Pressures. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 1000–1001, 3 figs. To determine condition of metal in high-pressure fittings, series of etching and X-ray tests were undertaken at Watertown Arsenal; tests disclose defects which experts at foundry, where fittings were made, had no idea existed; summary of causes of defects.

High-Speed. See STEEL, HIGH-SPEED.

Ingots, Square. Improvement in High-Grade Steel Industry through Use of Turned Square Ingots (Verbesserung des Edelstahlbetriebes durch Verwendung abgedrehter Vierkantblöcke), P. Eyermann. Stahl u. Eisen, vol. 46, no. 32, Aug. 12, 1926, pp. 1083–1084, 3 figs. Reasons for discarding and subsequently resuming square ingot in high-grade steel industry; describes lathe for square ingots and gives operating results.

Jalcase. A New J. & L. Steel. Iron Age, vol. 118, no. 9, Aug. 26, 1926, p. 546. New steel, Jalcase, which is adaptable for forging and case-hardening and yet has machinability of ordinary free-cutting steels; developed by Jones & Laughlin Steel Corporation.

Properties. Change of Physical Properties of Iron and Steel in an A.C. Field (Versuche über eine Aenderung der physikalischen Eigenschaften von Stahl und Eisen im Wechselkraftfeld), K. Windmüller. Dinglers polytechnisches Jl., vol. 341, no. 12, June 1926, pp. 152–153. Experiments with steel balls for determining their hardness and toughness before and after treatment in a.c. field; also electric resistance of iron and steel wire before and after this treatment.

Silicon. See SILICON STEEL.

Spring. The Mechanical Properties of Four Heat-Treated Spring Steels, G. A. Hankins and G. W. Ford. Iron & Steel Inst.—Advance Paper, no. 6, for mtg. Aug. 1926, 26 pp., 15 figs. Investigation undertaken at National Physical Laboratory as part of systematic investigation of mechanical properties of steels commonly used in spring manufacture.

STEEL CASTINGS

German Developments. Steel Castings. Metallurgist (Supp. to Engineer, vol. 142, no. 3689), Sept. 24, 1926, pp. 136–138, 6 figs. Review of articles by R. Krieger, in Stahl u. Eisen, May 27 and June 30, 1926, discussing development of German steel-casting industry during past 25 years; includes interesting examples of remarkable steel castings; discusses possibility of using steel castings to bear stresses at high temperatures, up to 400 deg. cent.; future problems and difficulties to be overcome. Reviewer claims that articles furnish striking picture of real achievement.

Silicon Steel. The Properties of High-Silicon Steel (Ueber die Eigenschaften hochsilicierten Stahls), E. H. Schulz and H. Buchholtz. Zeit. für angewandte Chemie, vol. 39, no. 26, July 1, 1926, pp. 806–807; also translated abstract in Foundry Trade Jl., vol. 34, no. 523, Aug. 26, 1926, pp. 185–186. As shown by results of tests, silicon steel appears most promising for steel castings, provided due attention be paid in its manufacture, and more particularly in annealing, to special characteristics of steel alloyed with silicon; cast silicon steel has higher elastic limit and greater elongation than ordinary cast steel of like tensile strength.

STEEL, HEAT TREATMENT OF

Calculating Machines. Where Heat-Treatment Increased the Life of Machines, F. H. Colvin. Am. Machinist, vol. 65, no. 12, Sept. 16, 1926, pp. 473–475, 7 figs. Methods and equipment that have proved successful in plant of Monroe Calculating Machine Co., Orange, N. J.

Die Blocks. Heat Treatment of Die Blocks, A. J. Porter, Jr. Am. Soc. Steel Treating—Trans., vol. 10, no. 3, Sept. 1926, pp. 447–456. Outlines development of die blocks to meet demands placed upon them through rapid growth of drop-forging industry; explains ways in which die blocks are mistreated, which causes breakage; advances arguments for heat-treated die block.

Tentative Recommended Practices for the Heat Treatment of Plain and Alloy Steel Die Blocks. Am. Soc. Steel Treating—Trans., vol. 10, no. 3, Sept. 1926, pp. 477–486. Tentative recommended practice for heat treatment of cold and hot-forming die blocks and of alloy-steel die blocks, cold heading dies, and die blocks for silverware.

Electric. Heat-Treating Axe Bits by Electricity, C. H. Carpenter. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, pp. 481–483, 2 figs. Use of electrically heated lead bath permits accurate temperature control; description of apparatus and results obtained; at plant of Kelly Axe & Tool Co., Charleston, W. Va.

Heat-Treating Axle Shafts by Special Machinery, F. C. Hudson. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, pp. 485–486, 2 figs. Electrically heated furnaces with air-operated devices for placing and removing work; mechanical quenching; automatic timing of work in furnace.

Manganese Steel. How to Treat Manganese Steel, Dr. B. Egeberg. Iron Age, vol. 118, no. 11, Sept. 9, 1926, pp. 676–678, 5 figs. Experience with both cast and forged product; manufacture and heat treatment of austenitic type.

Nickel Steel. Effect of Heat Treatment on Nickel Steel, J. Trantim, Jr. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, pp. 293–294. Compilation of data on physical properties of rolled electric nickel steel, heat treated by quenching in water and drawing at various temperatures.

Tractor Parts. Heat-Treating "Caterpillar" Parts, L. C. Morrow. Am. Mach., vol. 65, no. 12, Sept. 16, 1926, pp. 477–480, 8 figs. Methods and equipment of Caterpillar Tractor Co., San Leandro, Cal.; equipment for hardening and testing.

STEEL, HIGH-SPEED

Lathe Cutters. The Performance and Testing of High-Speed Steel Cutters (Die Leistung von Schnellstahlmessern und ihre Prüfung), F. Rapatz. Stahl u. Eisen, vol. 48, no. 33, Aug. 19, 1926, pp. 1109–1116 and (discussion) 1116–1117, 35 figs. partly on supp. plates. Investigations of high-speed steel cutters; influence of hardening temperature and nature of hardening, annealing, cutting speed, and properties of workpiece on time required for cutting.

STOKERS

Underfeed. Over-Fire Air Injection with Underfeed Stokers. M. K. Drewry. Power, vol. 64, no. 12, Sept. 21, 1926, pp. 446–447, 2 figs. Experience of Milwaukee Elec. Ry. & Light Co., summarized from its test reports, shows how to reduce smoke and increase efficiency in installations having small furnace volume.

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TESTS AND TESTING

Metal. The Mechanical Engineer and Testing Materials (Konstrukteur und Materialprüfung), L. Traeger. Maschinenbau, vol. 5, no. 15, August 5, 1926, pp. 689–692. Testing metals for tensile strength and limit of elongation; dynamic elongation and limit of elasticity, standards for dynamic testing of materials, etc., in connection with machine-shop practice.

THERMOMETERS

Refrigeration Plants. Thermometers and Other Instruments for Refrigeration Plants, R. Harrison. Ice & Cold Storage, vol. 29, no. 341, Aug. 1926, pp. 207–209, 7 figs. Dial and distance thermometers; recording thermometers or thermographs; indication of humidity.

TOLERANCES

Quantity Production, for. Checking Dimensions in Quantity Production (Le contrôle des dimensions des pièces mécaniques. Les tolérances), S. Thomas. Génie Civil, vol. 89, nos. 3, 4 and 5, July, 17, 24 and 31, 1926, pp. 56–59, 76–79 and 93–96, 12 figs. Discusses accurate and rapid checking of parts produced in quantities; formula to express error; limit gages and other devices for checking; tolerances, screw threads; relative diameters of holes and shafts in various types of assembly.

Unilateral. Standardize on the Unilateral Tolerance, F. C. Hudson. Am. Mach., vol. 65, no. 13, Sept. 23, 1926, p. 535. One of advantages of use of unilateral tolerance is that standard gages can be used for "go" gages for both holes and shafts, except for shrink and force fits; bilateral tolerances or where basic dimension is not used in one-way tolerances, require that all gages be special.

TOOL STEEL

Selection of. Selection of Proper Material for Tool Manufacture, J. B. Mudge. West. Soc. Engrs.—Jl., vol. 31, no. 8, Aug. 1926, pp. 295–305, 7 figs. Reviews practice by company in selecting raw material such as tool steel; selection of steel for job.

TRACTORS

Crankcase Dilution. Crankcase Dilution in Kerosene Tractors, L. G. Heimpel. Agric. Eng., vol. 7, no. 8, Aug. 1926, pp. 273–275, 2 figs. Results of investigation seem to indicate that close relationship exists between mechanical condition of engine and rate of dilution.

TRADE UNIONS

American. Organization and Membership of American Trade-Unions, 1926. Monthly Labor Rev., vol. 23, no. 2, Aug. 1926, pp. 8–23. Summary of bulletin of U. S. States Bureau of Labor Statistics, which is compendium of organization, form of government, and jurisdictional boundaries of existing American trade unions, and gives for each union brief account of its origin and history; outline of its benevolent activities and most recent and accurate membership figures obtainable.

TURBO-GENERATORS

80,000-Kw. Construction of an 80,000-Kw. Generator, J. R. Taylor. Elec. World, vol. 88, no. 10, Sept. 4, 1926, pp. 465–468, 6 figs. Design details of cross-compound base-load turbo-generator to be installed by Brooklyn Edison Co. in Hudson Avenue station.

V

VALVE GEARS

Locomotive. The Walschaert Valve-Gear for Locomotives, H. T. Davey. Mech. World, vol. 80, no. 2065, July 30, 1926, p. 82, 2 figs. Points in favor of this form of valve gear are its accessibility, with consequent ease of adjustment, together with provision of constant lap and lead for all points of cut-off; Walschaert gear is extensively used for engines having cylinders outside frames, and with steam chests in same vertical plane overhead; motion of valve; adjustments.

VALVES

Motor-Operated. Motor Operated Valves Aid Plant Operation. Power Plant Eng., vol. 30, no. 18, Sept. 15, 1926, pp. 1001–1004, 4 figs. Principal details of valves and controls, costs of installing and applications.

VIBRATION

Elimination Of. Insulation Against Noise and Vibrations (Isolierung gegen Geräusche und Erschütterungen), W. Speiser. Dinglers polytechnisches Jl., vol. 341, no. 11, June 1926, pp. 117–120, 12 figs. Discusses insulating properties of cork and use of "Korfund" sheets of cork wood in iron frames for foundations of various machines to eliminate vibration, also resulting in smoother running.

VOCATIONAL TRAINING

Psychophysiology. Some Experiments in Vocational Psychophysiology, L. Walther. Int. Labour Rev., vol. 14, no. 1, July 1926, pp. 55–71. Author's experiments show practical results which may be expected from judicious application of physiology and psychology to vocational activities; vocational selection and training; application of motion study to industrial work; industrial fatigue.

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WASTE ELIMINATION

Industrial. Elimination of Waste in Industry, W. C. Wetherill. Forging—Stamping—Heat Treating, vol. 12, no. 8, Aug. 1926, pp. 271–274. What Department of Commerce has accomplished in elimination of waste in industry; points out that average industrial waste is 49 per cent. Paper presented before Am. Drop Forging Inst.

Lowering Costs by. Lower Costs by Waste Elimination, C. B. Auel. Am. Mach., vol. 65, no. 15, Oct. 7, 1926, pp. 597–598. Points out that lack of standardization has more to do with high cost of living than any other one thing; recommends salvage department to study and correct apparent losses.

WATER PIPE

Corrosion. The Prevention of Corrosion of Pipe, W. W. Brush. Am. Water Works Assn.—Jl., vol. 16, no. 2, Aug. 1926, pp. 173–176 and (discussion) 177–180, 1 fig. Condition of pipe recently uncovered in Brooklyn portion of New York distribution system illustrates protection of metal and condition that develops with soft corrosive water with inadequate protection of metal.

WATER POWER

N. E. L. A. Committee Report. Report of Hydraulic Power Committee 1925–1926. Nat. Elec. Light Assn.—Report, no. 256–26, May 18, 1926, 30 pp., 24 figs. Contains following reports: Reliability of Hydro-Electric Units; Forecasting Water Supply; Vibration in Hydraulic Machinery; Restriction in Flow Due to Vegetable and Animal Growths in Conduits; Manufacturers' Statements Regarding Developments in the Hydraulic Field, 1925. Bibliography.

WATER TREATMENT

Railway Plants. Water Treating Plant on the Illinois Central. Ry. Elec. Engr., vol. 17, no. 9, Sept. 1926, pp. 289–291, 5 figs. Full automatic-control equipment with several unique features incorporated in new installation at Harvey, Ill.

WELDING

Cast Iron. Oxyacetylene and Electric Welding of Cast Iron (Autogenes und elektrisches Schweissen von Gusseisen), P. Schimpke. Stahl u. Eisen, vol. 46, no. 34, Aug. 26, 1926, pp. 1141–1148, 20 figs. Present status of welding-equipment design; general principles of cast-iron welding; oxyacetylene and electric cold and hot welding of cast iron and examples of welds; efficiency and costs.

Electric. See ELECTRIC WELDING; ELECTRIC WELDING, ARC.

Oxyacetylene. See OXYACETYLENE WELDING.

WINDING ENGINES

Overspeed Prevention. Overspeed and Overwind Prevention. Iron & Coal Trades Rev., vol. 113, nos. 3046 and 3047, July 16 and 23, 1926, pp. 88–90, 124–125, 17 figs. Examples of German practice. Translated from article by H. Hoffman, in Glückauf.

WIRE DRAWING

Continuous. Continuous Wire Drawing, K. B. Lewis. Wire, vol. 1, nos. 3 and 4, July and Aug. 1926, pp. 79–80 and 99–100; and 116–117 and 140–141, 6 figs. Discusses various types of continuous wire-drawing machinery.

Mechanical Phenomena. Mechanical Phenomena in the Die Plate in Wire Drawing (Ueber die mechanischen Vorgänge im Ziehkanal beim Ziehen von Drähten), E. Siebel. Zeit. für Technische Physik, no. 7, 1926, pp. 335–345. Discusses distribution of stresses in die plate; calculates effect of friction; phenomenon of wire drawing.

WOODWORKING MACHINERY

High-Speed. High-Speed Woodworking Machines. Engineering, vol. 122, no. 3162, Aug. 20, 1926, pp. 230–231, 3 figs. Details of glue jointer and edge molder, three-drum endless bed sander, and automatic cut-off saw, manufactured by J. A. Fay and Egan Co., Cincinnati, Ohio.

Modern. Workshop Experience with Modern Woodworking Machinery, J. Gillrath. Eng. Progress, vol. 7, no. 7, July 1926, pp. 192–195, 7 figs. Advantages of electrically driven woodworking machines; details of exhibit at Leipzig Spring Fair.